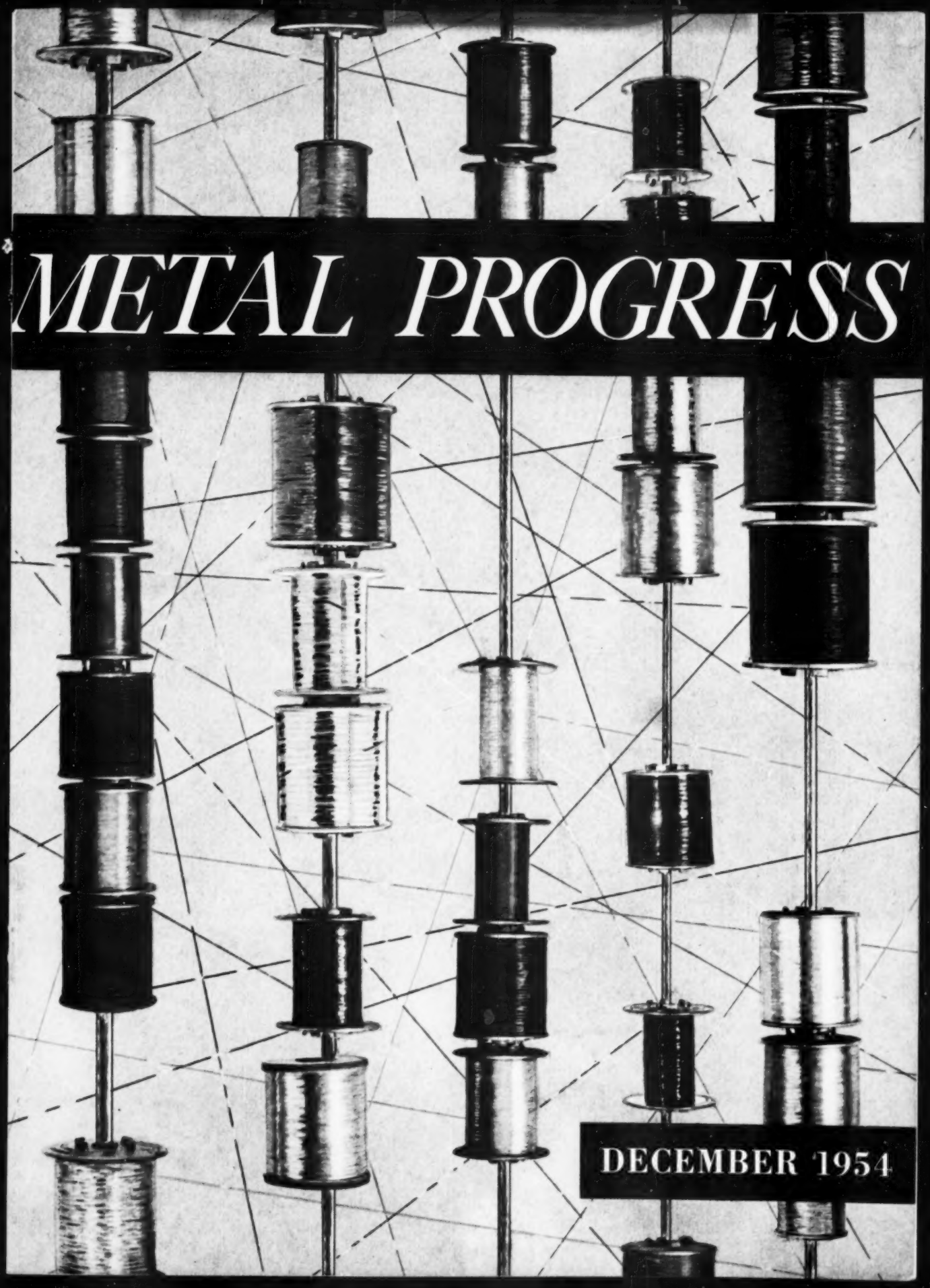
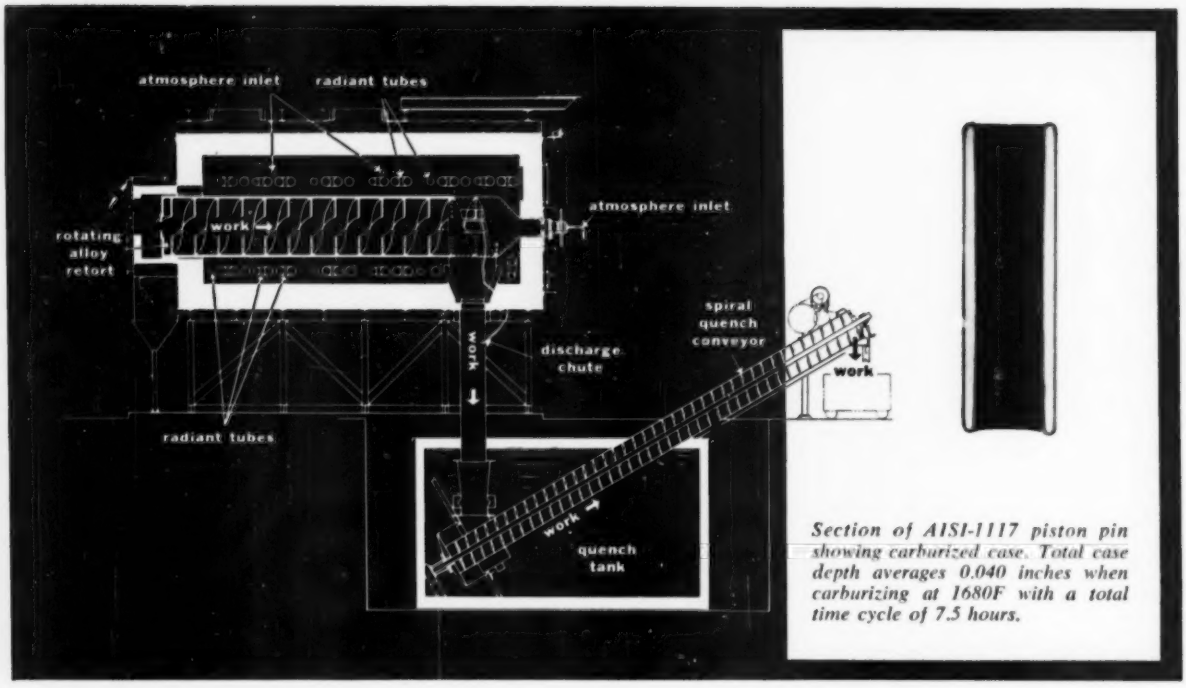


METAL PROGRESS

DECEMBER 1954



Section of AISI-1117 piston pin showing carburized case. Total case depth averages 0.040 inches when carburizing at 1680F with a total time cycle of 7.5 hours.

Chrysler increases production, improves quality of piston pins

WITH 'SURFACE' ADVANCED GAS CARBURIZING

When Chrysler Division metallurgists replaced pack carburizing of piston pins with gas carburizing they selected a 'Surface' rotary retort continuous gas carburizer and RX® gas generator. Four big dividends have justified that selection:

1. **Production increased** to 550 pieces per hour.
2. **Overall time reduced**—two heat treat operations eliminated.
3. **Work quality improved**—tumbling action of parts in the rotating retort exposes all surfaces to the carburizing atmosphere.
4. **Quenching improved**—the furnace delivers a steady flow of a few pieces at a time to the quench tank.

You can modernize your carburizing operations with 'Surface' equipment. Continuous furnaces are available in many types and sizes to meet your production requirements. Your 'Surface' engineer can help you select the equipment for your job.

Call him in today, or write for Literature Group H54-3.

Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

Metal Progress

December, 1954 **Vol. 66, No. 6**

Ernest E. Thum, *Editor*
Marjorie R. Hyslop, *Managing Editor*
John Parina, Jr., *Associate Editor*
Floyd E. Craig, *Art Director*

Cover by Martha A. Horvath

A design wrought by brilliantly colored spools of metallic thread won first prize in *Metal Progress*'s annual competition at the Cleveland School of Art.

Engineering Articles

Table of Contents Continued on Page 3 (Volume Index Facing Page 200)

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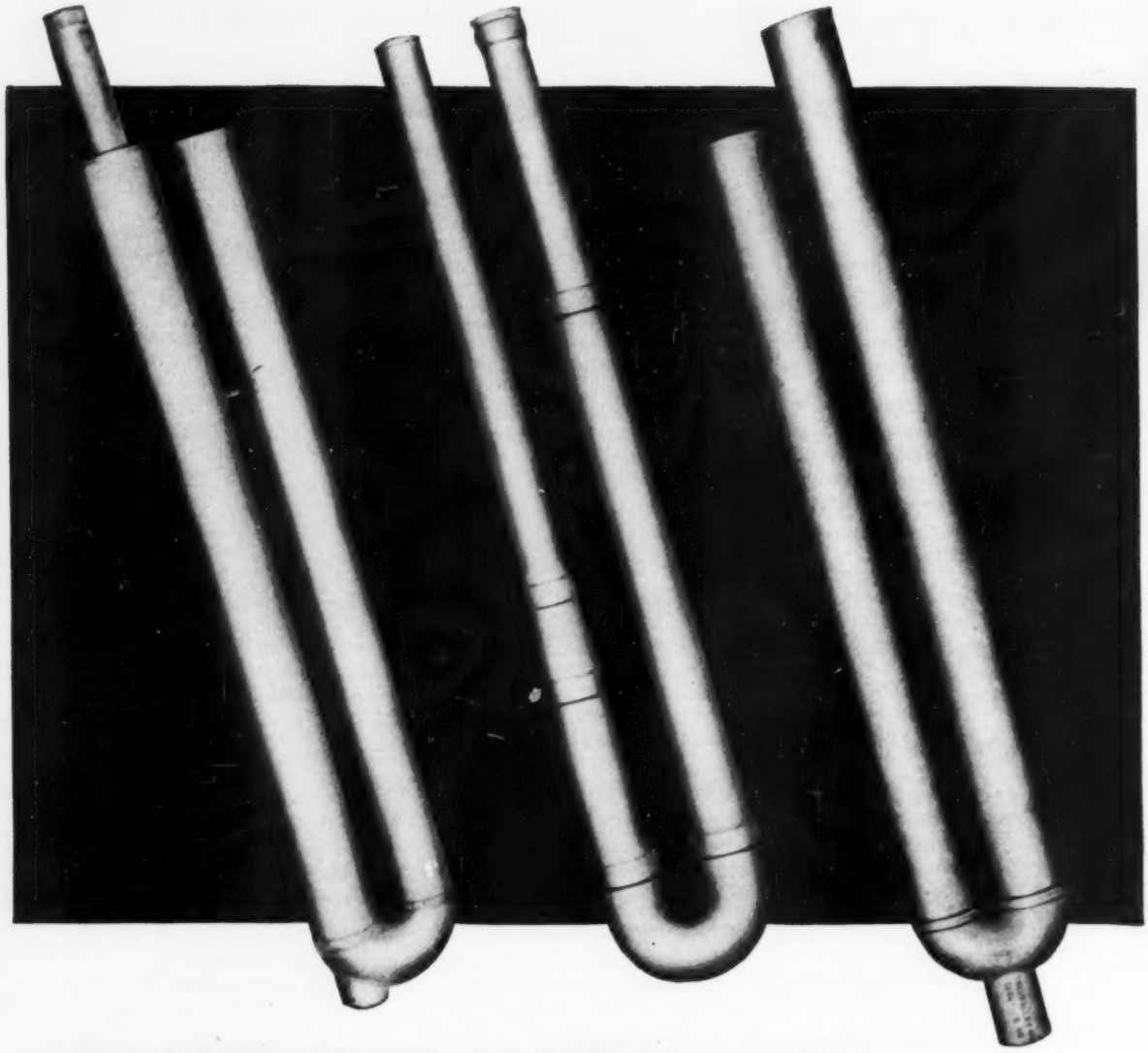

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Thermalloy* radiant tubes

Make Electro-Alloys your source if you want radiant tube assemblies that will give more life and reduce maintenance costs.

All components are produced in suitable analyses under close metallurgical supervision, and with X-ray control. The straight tube sections are centrifugally cast in such a way that wall thickness is uniform throughout; i. e., inside diameter and outside diameter are concentric, and thickness is the same the full length of the tube. All finished assemblies are pressure-tested before shipment to insure freedom from leakage. As a result, you are assured of radiant tube assemblies that last longer without cracking, warping or sagging.

Whatever your needs in radiant tube assemblies or other heat-treating equipment—you'll get more operating economy from high heat-resistant Thermalloy castings. Let us know your requirements. Call your nearest Electro-Alloys engineer or write Electro-Alloys Division, 5002 Taylor Street, Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

ELYRIA, OHIO

*Reg. U. S. Pat. Off

Table of Contents Continued . . .

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Seventy-five years of experience is behind the quality and performance of Finkl products. Take advantage of that knowledge. Call the Finkl representative nearest you the next time you are planning your die blocks or forgings.

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1879 F 1954 75th ANNIVERSARY

A. Finkl & Sons Co.

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FORGINGS · DIE BLOCKS · ELECTRIC FURNACE STEELS

As I was saying...

AND as I hope to continue saying for many years to come – Merry Christmas and Happy New Year. It's always a joy to say it to my friends and I know that you feel as I do that you get "something" when you say it even to a stranger.

Now that I have started out this December column with best wishes to you, I cannot help but write a few words about the great Chicago Metal Show and Metal Congress. These events have just been put to bed, all the members have checked out of the hotels, and the cartage contractor has just about cleared the 300,000-sq. ft. building of the last vestige of the greatest Metal Exposition in history. Never was there a greater array of new products and processes than that presented by the 424 exhibitors. Never was the attendance so satisfying to exhibitors and management. More than 65,000 came, morning, afternoon and evening, to feast their inquiring minds on the galaxy of unusual and outstanding advances in the metal-producing and fabricating fields.

You'll recall I made some predictions at the close of my message last month – and I'll have to admit now that based on what other people say (as well as my own perceptions), the predictions I made were understatements of the highest order.

The technical sessions, the Campbell Lecture (by Dr. Kent R. Van Horn), the Seminar, the special meetings, and the annual meeting of the I.H.E.A. played to SRO and they all deserved the high interest their subjects generated.

Members at the ASM's annual meeting listened to the reports of national officers with interest and when it came time for the secretary's report, I skipped over the usual statistical information and presented my plan for the "A.S.M. of Tomorrow". You may recall that I've hinted about the possibility of such a report in preceding columns – and in fact, the plan had been submitted to the Board of Trustees and to the past presidents. But the first presentation to the membership and the public was at the annual meeting. As I said then, and I repeat now, I'm very happy to have been the author of the proposed progressive advancement of the A.S.M. so that the Society may be better able to serve the great metal industry.

To those who were unable to attend the annual meeting, you may – and I hope you will – read it in this issue of *Metal Progress* following p. 80. It's a great opportunity for you and for all of us to work shoulder to shoulder in a colossal activity that we can win if we have faith in the "A.S.M. of Tomorrow"!

Cordially,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

Whatever your furnace needs for control—

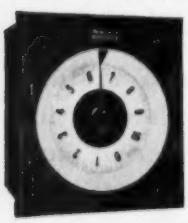
There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Just check through the requirements of your specific heat-treating problem . . . then look through this group of instruments and accessories:

Choose *ElectroniK* Strip Chart Controllers for detailed, long-term records . . . and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action.

Choose *ElectroniK* Circular Chart Controllers for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.

Choose *ElectroniK* Circular Scale Controllers where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.



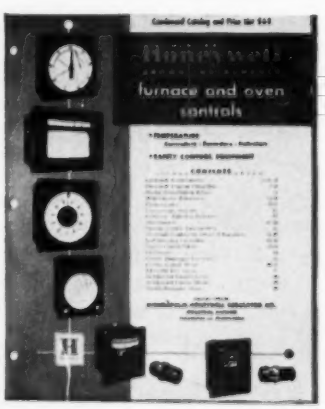
Choose *Pyr-O-Vane* Controllers where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument.

Choose *Protect-O-Vane* Controllers for simple, dependable excess temperature cut-off protection.

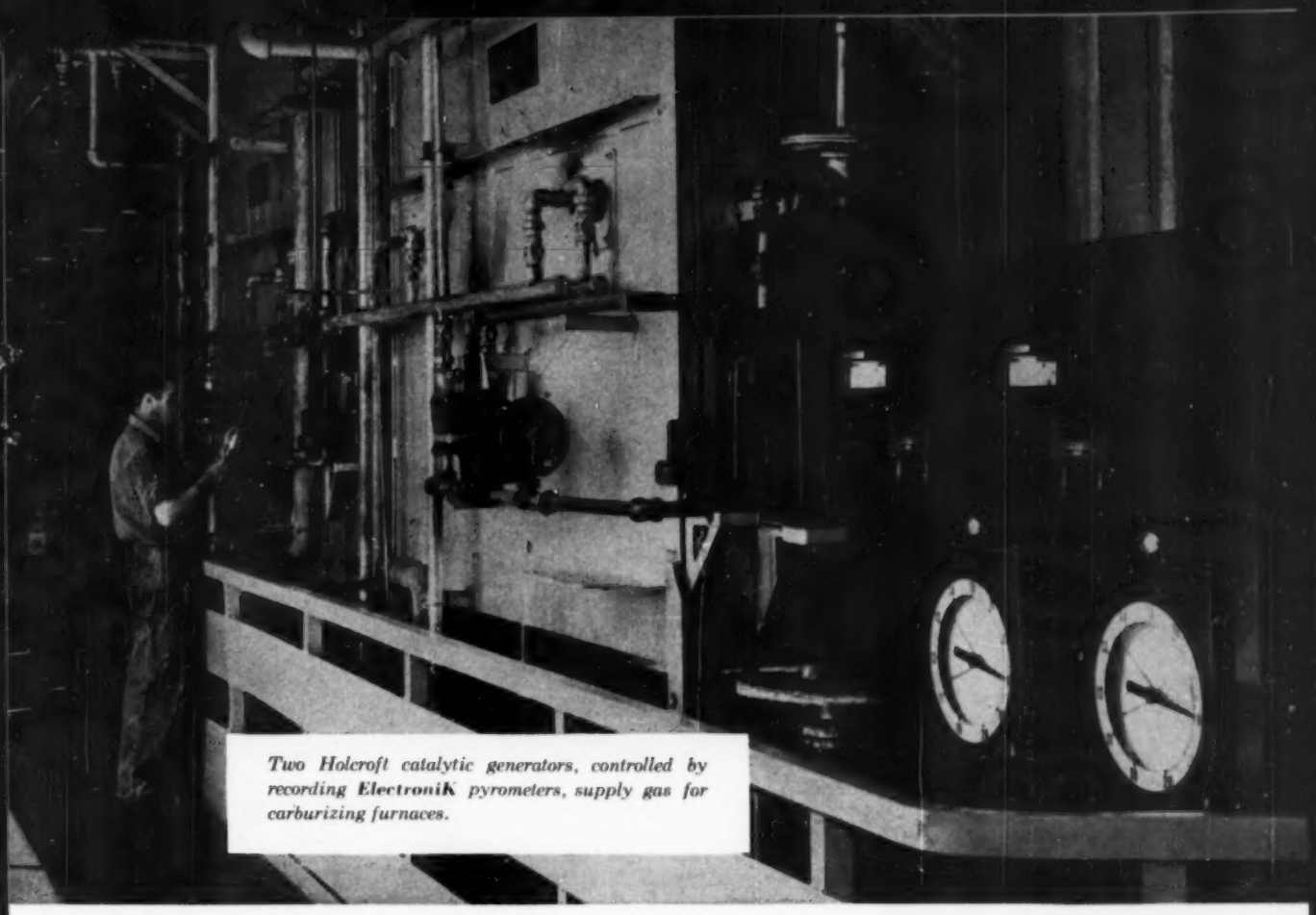
• • •

And for all your pyrometer supplies, investigate the HSM Plan—the convenient way to buy the best in supplies on a schedule custom-fitted to your plant . . . at advantageous discount schedules.

Precision control assures correct atmosphere for carburizing



Detailed information on all Brown instruments for regulating heat-treating equipment is contained in Catalog 54-1, "Furnace and Oven Controls" . . . complete with up-to-date prices. Write for your copy today . . . or get one from your local Honeywell sales engineer next time he calls.



Two Holcroft catalytic generators, controlled by recording ***ElectroniK*** *pyrometers, supply gas for carburizing furnaces.*

Ford transmission shafts

THE MECHANIZED heat-treating facilities at Ford Motor Co.'s Mound Road plant carburize about 480 transmission shafts per hour. Supplying carburizing gas of exactly the right composition is essential to the quality of this high production operation. And, like many other heat-treating problems, gas generation profits by the accuracy of *ElectroniK* control.

Carburizing gas is produced by two Holcroft units, each having a capacity of 3600 cubic feet per hour. Used one at a time, with the other as standby, these units feed gas to a pair of pusher-type Holcroft furnaces.

Natural gas and air are cracked catalytically in the generating unit to produce the carrier gas. Responsibility for keeping cracking temperatures within exacting limits is assigned to *ElectroniK* Controllers, which regulate fuel input to the six burners heating the combustion retort. Regardless of changes in fuel pressure and gas demand, these instruments maintain cracking temperatures with the precision required for accurate control of gas analysis.

Whatever your own heat-treating problem, you'll get the best in control performance with *ElectroniK* instrumentation. The choice of leading furnace manufacturers, these controllers have proved their performance and dependability in thousands of heat-treating departments. It will pay you to specify *ElectroniK* instrumentation on any furnaces you're planning for new plant or for modernization programs.

Your nearby Honeywell sales engineer will be glad to discuss your specific requirements . . . and he's as near as your phone.

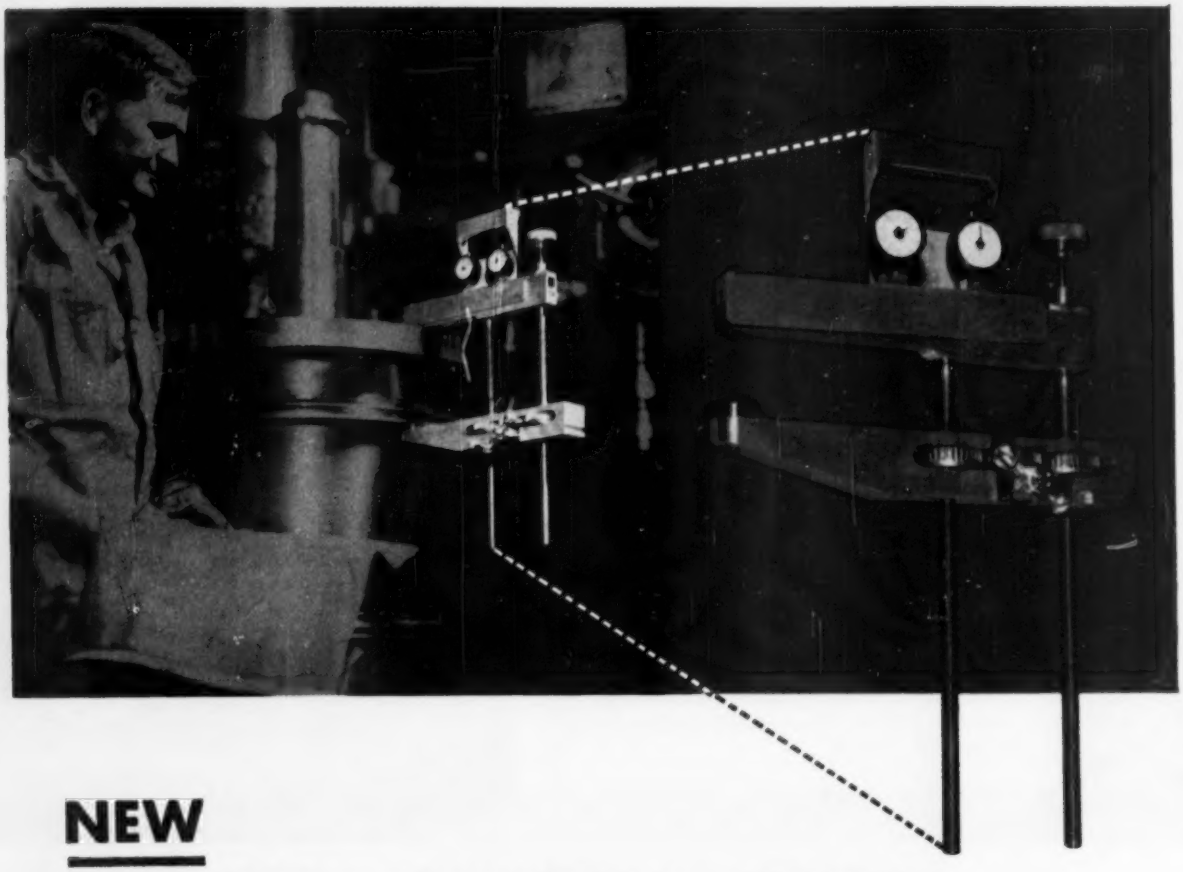
MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for Catalog 54-1, "Furnace and Oven Controls."**

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

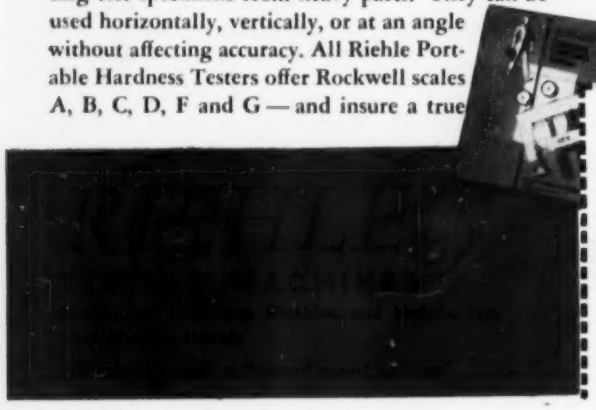


NEW
PORTABLE HARDNESS TESTERS MAKE TESTS ON THE SPOT

These new Riehle Portable Hardness Testers easily test *inside* and *outside* surfaces of parts inaccessible or difficult to test on bench machines. Riehle portables weigh but a few pounds. And each unit, plus included equipment, comes in a handy carrying case.

Riehle portables save the time *and expense* of cutting test specimens from heavy parts. They can be used horizontally, vertically, or at an angle without affecting accuracy. All Riehle Portable Hardness Testers offer Rockwell scales A, B, C, D, F and G — and insure a true Rockwell test. These testers use standard indentors with standard Rockwell loadings. There are no errors due to conversion from other scales.

Riehle portables are available in Models PHT-1 and PHT-2 which have respective capacities of 4½ inches and 12 inches diameter or thickness. NEW FREE BULLETIN contains specifications and application photographs. Send for your copy.



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Yes, send me the new FREE Bulletin RH-12-54 on Riehle Portable Hardness Testers.

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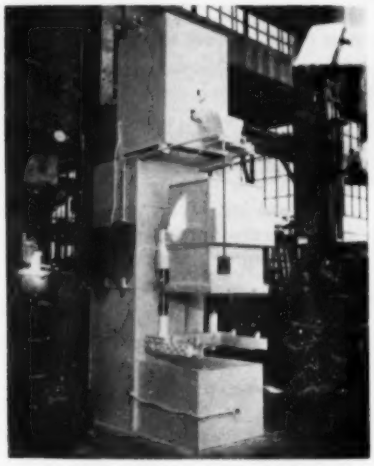
NAME AND TITLE

Shell Molding

A fully automatic, complete, shell investment unit for producing shells up to 24 x 30 in. has been announced by Beardsley & Piper. It forms up to six shells per min., though actual production from the unit will depend



upon the shell curing capacity provided. The shell investor features precise investment time control, metered sand resin addition, controlled sand resin rainfall and thorough lump scavenging. It may be used with any curing and stripping equipment.

For further information circle No. 1916 on literature request card on p. 36-B.

Hydrogen Control

Hydrogen content of titanium metal and alloys can be determined in less than 20 min. by using a vacuum fusion gas analysis apparatus, which has been announced by National Research Corp. Since small concentrations of hydrogen in titanium metals and alloys may have critical and adverse effects on their physical properties, this new technique can be used to eliminate costly work on defective titanium or titanium alloys.

For further information circle No. 1917 on literature request card on p. 36-B.

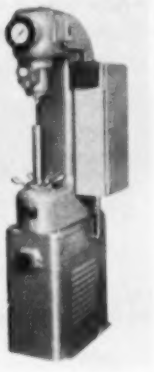
Atmosphere Furnace

A new inert-atmosphere, arc-melting furnace for melting highly reactive or refractory metals has been announced by the General Electric Co. Available in two models, fixed electrode and consumable electrode, the new furnace has been used for melting molybdenum, tungsten, tantalum, zirconium, titanium, and their alloys as well as more common metals such as iron and aluminum. The fixed-electrode model consists of a controlled atmosphere chamber; water-cooled tungsten-type electrode; adjustable, automatic control for rotation of the electrode; water-cooled copper mold; control system; magnetic field to stir the pool of molten metal; high vacuum system; vibratory-type feeder and d-c. power source. For operation as a consumable electrode furnace, an evacuated housing is used both to hold and feed the prefabricated electrode.

For further information circle No. 1918 on literature request card on p. 36-B.

Hardness Tester

Three colored lights signal the relative Brinell hardness of the test piece on Steel City Testing Machines' new color-glance Brinell hardness testing machine. Yellow indicates "too hard", green designates "within range" and red shows "too soft". Limits are adjustable to suit the requirements of each job. Basically, the new machine is the same as the company's direct reading type tester. A dial indicator with adjustable electric contacts has been substituted for the standard indicator previously used, and this is connected to the specially-designed control panel.



For further information circle No. 1919 on literature request card on p. 36-B.

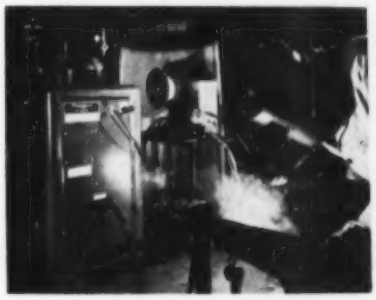
Jet Descaler

A new descaler was displayed in November at the National Metal Exposition in Chicago by the Commercial Shearing and Stamping Co. Oil is used to actuate a compound piston which pressurizes water up to 2000 psi. The pressurized water is directed to the hot metal surface through a cone ring orifice in an inverted spray cone pattern and not in a nozzle directed spray. Completely penetrating the steam blanket, a dense solid sheet edge of water strikes the hot metal surface in direct contact. There is very little temperature drop in the hot metal. The machine capable of handling stock up to 3 in. in diameter occupies floor space 2 by 12 ft. Height is 40 in.

For further information circle No. 1920 on literature request card on p. 36-B.

Arc Welding

Westinghouse Electric Corp. has announced a new consumable-electrode, inert, gas, arc welding process. Basic features of the process are a new coated wire, a newly designed welding

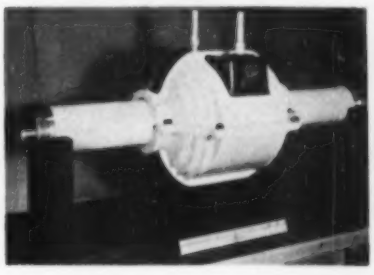


gun, welding feed-wire control and a d-c. arc welder. The process makes it economically possible to weld mild steel with a consumable electrode. Steel from 1/16-in. up can be fillet, lap or butt welded. The system can be set up to operate semi-automatically or automatically. The process is intended for horizontal or flat position welding but is not developed for vertical or overhead welding.

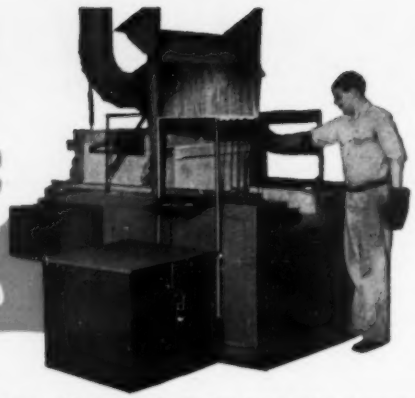
For further information circle No. 1921 on literature request card on p. 36-B.

Magnetic Flow Meter

A new electromagnetic flow meter, designed for 2 to 8 in. flow lines, has been introduced by the Foxboro Co.



FASTER, LOWER COST Hardening FOR ALL Engineering Steels



No Scale... No Decarb

Full hardness with no decarburization (even under microscopic examination) of silicon-manganese steel gears is obtained by a machine tool producer in this Ajax salt bath installation.

No other device approaches Ajax neutral salt bath efficiency in hardening steels . . . low carbon, high alloy, stainless, high-carbon high-chrome, high speed types . . . *because only Ajax protects the work so effectively from atmospheric effects.*

All air is "sealed out." A film of salt protects the work up to the instant of quenching . . . keeps the surface clean. Scaling, pitting, carburizing and decarburization are avoided.

LOW COST — First cost of equipment is only ½ to ⅓ that of any other production hardening system!

RAPID HEATING—Heating cycles from 4 to 6 times faster than in radiant type furnaces assure greater production in less time. Distortion is negligible.

UNIFORM RESULTS—*Uniform* physical properties result from *uniform* bath temperatures . . . and, in the Ajax furnace, a temperature variation of less than 5°F is held throughout. Smaller equipment in less space produces a given output. Unskilled labor can handle the entire process.

ADAPTABILITY—Selective heating is easily obtained by immersing only that portion of the work to be hardened. A unique method for hardening gear or sprocket teeth is to spin them in salt, immersing only the teeth.

WRITE FOR Ajax Catalog 116B, also list of documented case histories of hardening installations.

SEND your specimen parts to the Ajax Metallurgical Service Laboratory for treatment. No cost or obligation.

Fast COMPLETELY MECHANIZED HARDENING

4-pound spline shafts loaded 4 shafts to a fixture, and up to 10 fixture loads at a time, are hardened at 1550°F. in a mechanized Ajax salt bath furnace. They are automatically quenched in water followed by a nitrate salt draw at 600°F. The Ajax furnace has operated day in and day out 24 hours a day for over a year without interruption.

5400 BLADES A Day

Good carving knives need exceptionally hard, tough cutting edges . . . and these blades of 440 stainless steel have them! 150 lbs. of work per hour, or 5400 blades per day, are handled in a single Ajax salt bath furnace by one unskilled operator.

MORE WORK IN Less Space

Aircraft landing gears of SAE-4340 steel up to 62" long are hardened in Ajax salt bath furnaces by immersing them vertically in baths 75" deep. Over 800 pounds of work are processed per hour . . . Great space savings afforded by treating pieces vertically. Austenitizing furnace, requires less than 70 square feet of space.

No Rejects

On a run of 30,000 rock bits hardened with Ajax salt bath furnaces, not one was rejected. Bit life was increased 4 to 5 times by comparison with a previous hardening method. Plain carbon steel rather than costly alloy steel is used . . . 480 lbs. an hour are treated in a bath with working dimensions of only 36" x 11" x 36"! Hardness never varies more than 1 point from Rc52.

AJAX HULTGREN electric SALT BATH furnaces

World's largest manufacturer of electric heat-treating furnaces exclusively

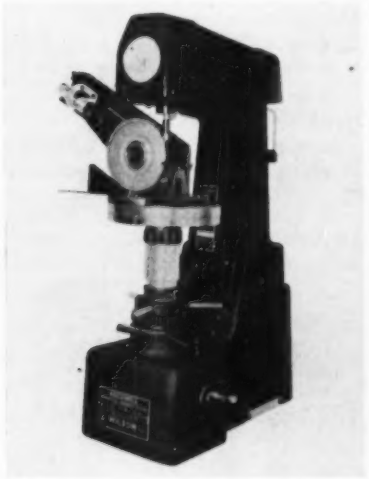
AJAX ELECTRIC COMPANY 910 Frankford Ave., Philadelphia 23, Pa.

Associate companies: Ajax Electric Furnace Corp.; Ajax Engineering Corp.; Ajax Electrothermic Corp.
In Canada: Canadian General Electric Co. Ltd., Toronto, Ont.

The meter will measure the volume flow rate of any liquid of sufficient conductance and velocity, unaffected by the pressure, viscosity, density or changes in conductivity of the flowing liquid. The unit consists of a non-magnetic flow tube with an insulating liner containing flush-mounted metallic electrodes and surrounded by an a-c. electro-magnet. When conductive liquid passes through the tube, an alternating voltage is set up between the electrodes which varies linearly in proportion to the flow rate. Lead wires from the electrodes transmit this voltage output to a new type electronic recorder, producing a chart record.
For further information circle No. 1922 on literature request card on p. 36-B.

Gear Testing Fixture

A new holding fixture by which gears may be quickly and accurately tested on the pitch line of gear teeth has been announced by the Wilson Mechanical Instrument Div. It is designed to use with a Rockwell superficial hardness tester with a special gooseneck type indenter. The gear is



placed on an inclined plane mounted on a sliding plate; the plate is then moved toward a positioning anvil which is designed to compensate for the diametrical pitch. The elevating screw is raised to bring the indenter into contact with the gear tooth. A lock screw on the base plate, used to lock the inclined plane in position, is then tightened.
For further information circle No. 1923 on literature request card on p. 36-B.

Cores for Large Castings

Chambersburg Engineering Co.'s Foundry Div. has announced the use of cement bonded sand to make a large core for a 48,000 lb. iron casting for an exhaust casing, without the use of the customary core box or the use of arbors. The mold for the outside of the casting was made first and lined with a layer of sand the exact thickness desired for the casting walls. The core was made within this layer of sand, removed, the sand lining stripped out of the mold, and, after checking the mold and core for accuracy, set in the mold for casting.

Natural hardening of the cement bonded sand and its high strength made it possible to produce the core with a minimum of internal reinforcing and no special equipment.
For further information circle No. 1924 on literature request card on p. 36-B.

Degreaser

Circo Equipment Co. has introduced a new design of degreaser. Special features include elimination of most rusting due to water condensation,

since water condensing on the coils will drop into the condensate pan and then into the water separator; water temperature regulation after water leaves cooling coil and before it enters water jacket, insuring accurate control between 90 and 120° F.; a new pump of stainless steel and nickel-clad steel; storage tanks as an integral part of tank body; copper tubing condensate coils; immersion burners.
For further information circle No. 1925 on literature request card on p. 36-B.

Locknut

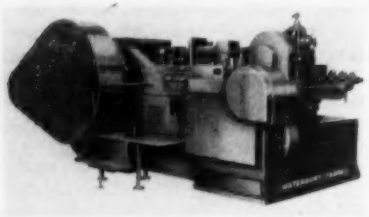
Allmetal Screw Products Co. has announced a solid metal locknut, slotted cone shape on one end, splined cylinder on the other. It is designed to be inserted in a countersunk hole. Nut is partially or completely seated in

the material and is held in position by force-fitted splines. After the bolt is inserted, locking action is effected by the pressure of the sector threads forced against the bolt by the interference of the countersinks. It is available in all metals and in all standard thread specifications. Locking action remains unaffected by high temperature conditions.

For further information circle No. 1926 on literature request card on p. 36-B.

Cold Heading

A new ⅛ in. solid die, double stroke header has been announced by Waterbury Farrel Foundry and Machine Co.



It will produce headed blanks up to 6 in. long from an 8 in. maximum wire cutoff, at 80 per minute. Shorter blanks can be headed at 100 blanks per minute. Wire is fed from the coil by a positive roll feed to the cutoff. This cutoff consists of a pair of thick blades held in slides to assure a clean, square cutoff. Wire blanks are then transported from the cutoff slides to the heading die. After being headed, blanks are ejected from the heading die by a knockout mechanism. Adjustments are provided to compensate for wear and to retime these mechanisms in relation to each other.

For further information circle No. 1927 on literature request card on p. 36-B.

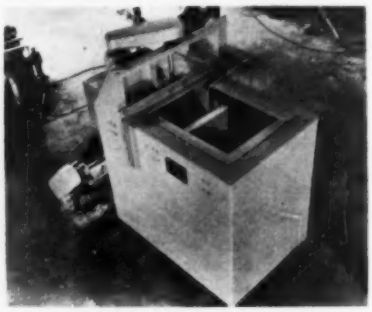
Stop-Off Paint

Park Chemical Co. has announced a metal stop to be used as a preparatory step to protect certain sections of a part prior to metallizing. It has a gray-white color which readily shows up the area to be protected. Its edge aligning is sharp and it is fast drying, free flowing and water soluble.

For further information circle No. 1928 on literature request card on p. 36-B.

Quenching Unit

A new gas fired hot salt or hot oil quenching unit has been announced by Industrial Heating Equipment Co. It is designed to operate in the range between 300 and 800° F., depending upon the selection of salt or oil. The container is heated by recirculating hot air around all the surfaces of the pot. The temperature of the hot salt or oil is held by temperature control arrangement. If the salt or oil rises



above the desired operating temperature, the gas is shut off and cold air is admixed to the circulating gases to reduce the salt or oil temperature. When the salt or oil drops below the desired temperature the gases come back on, resulting in close control. Agitation of salt or oil is provided by a propeller immersed in one section of the pot with the duct work so constructed as to produce uniform velocity throughout.

For further information circle No. 1929 on literature request card on p. 36-B.

Stress-Rupture Testing

A new creep and stress-rupture frame assembly has been announced by Labquip Corp. The frame has been designed to provide accurate test results while permitting simplified control and reducing maintenance. Main component of the lever system — the load lever — is cut from solid steel or aluminum. Its accuracy is ±0.5%. Knife edges are precision machined, heat treated and cadmium plated to prevent corrosion. A shock absorber is provided to take the impact when the specimen ruptures and the safety stop (an integral part of the frame) restrains the lever

3 POINTS TO REMEMBER

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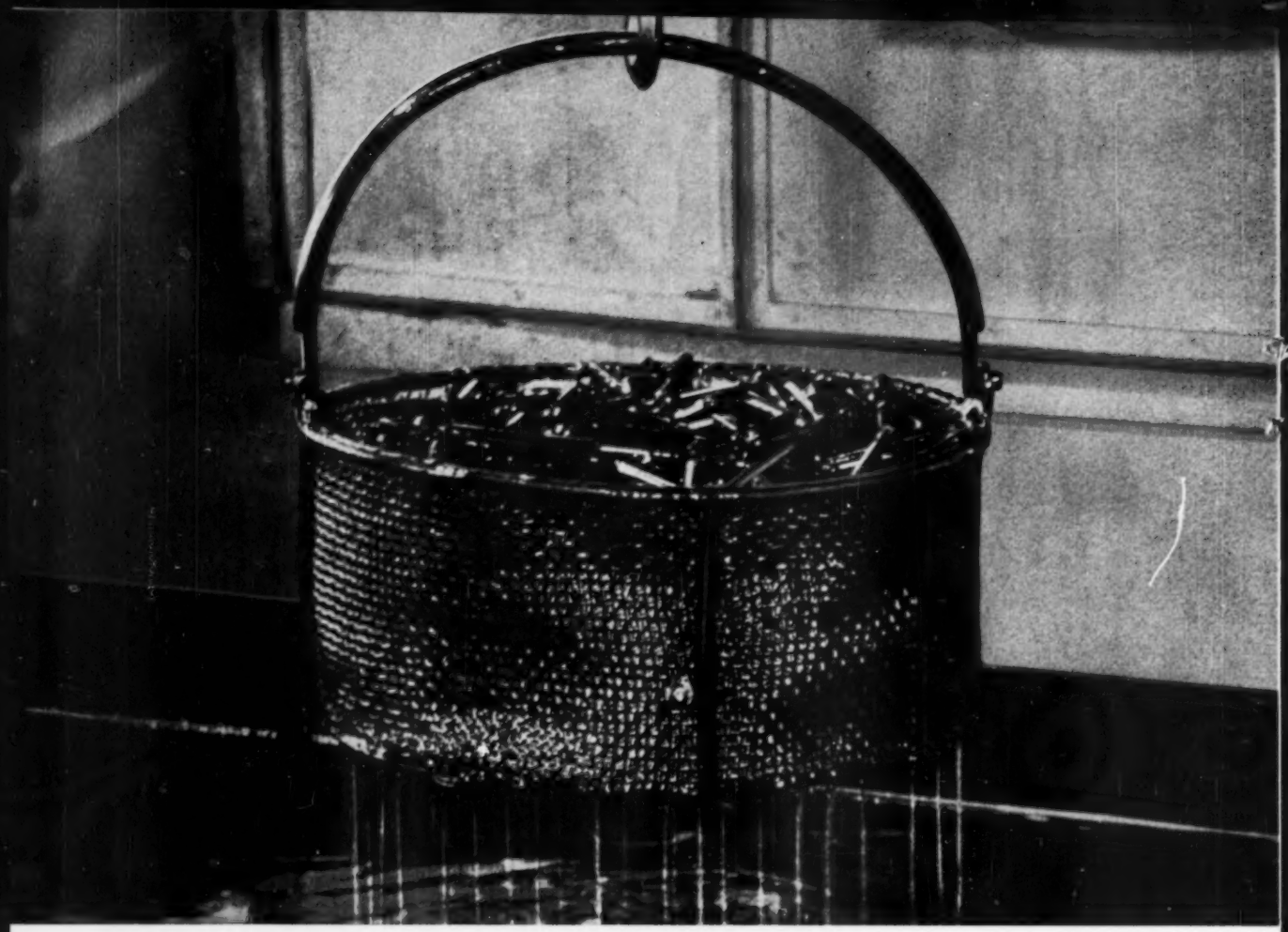

You Get Minimum Drag-out with Sun Quenching Oil Light

When you reduce oil consumption by lowering drag-out, you cut a major cost in operating a quenching system. Sun Quenching Oil Light thins out when heated, drains off parts faster and more completely. And Sun Quenching Oil Light, because of its natural detergency, prevents the formation of sludge deposits, aids in removing any deposits that have accumulated. And under normal operating conditions it need never be replaced. Sun's booklet "Sun Quenching Oils" tells about this low-cost oil. For a copy, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-12.

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if an overload is applied, thus preventing damage to the furnace, specimen and knife edges. An elevating screw permits rapid placement of specimens and adjustment. Frames of 12,000, 5000, and 2500 lb. capacity are standard. The maximum usable distance between cross-heads on the standard apparatus is 35 in.

For further information circle No. 1930 on literature request card on p. 36-B.

Monel Fixtures

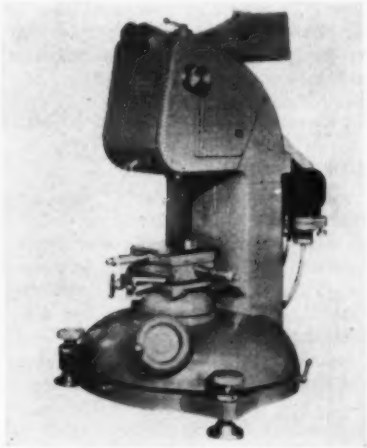
A chain sling entirely of Monel metal has been announced by the Stanwood Corp. It is intended for use in handling large parts, or baskets or containers in and out of pickling tanks,

degreasing solutions, or acid baths. The bottom ends of the four chains on the sling can be equipped with various sizes and shapes of retaining rings or with hooks. The oval rings shown were designed to slip over projecting lugs on the pickling crate for which this sling was made.

For further information circle No. 1931 on literature request card on p. 36-B.

Surface Measurement

Engis Equipment Co. has announced a surface micro-interferometer which permits measurement in terms of wave lengths of light. The microinterferometer is sturdy, direct measuring, quick and simple of control and adaptable to jobs of various sizes without changing parts. The instrument is self checking and it can provide a permanent record.



For further information circle No. 1932 on literature request card on p. 36-B.

High Speed Steel Saw Band

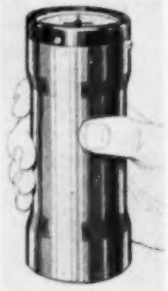
Because of recent advances by tool steel fabricators and heat treatment and welding techniques developed by the DoAll Co., the superior performance of high speed steel is now available for saw band users. This permits two to three times greater band tool velocity than that possible with high-carbon steel blades; its greater tensile strength allows heavier work feeds and chip loads with no sacrifice in accuracy. When high speed steel tools were first introduced on lathes and other machines, it quickly became apparent that the existing machines were underpowered and insufficiently rigid to handle the work load of which the high speed steel tools were capable. Similarly, the cutting potential of DoAll's new blade made it imperative to design and develop band machines of more rugged construction and with vitally needed coolant facili-

ties. The new machines together with the new saw bands have produced excellent results.

For further information circle No. 1933 on literature request card on p. 36-B.

Gas Analysis

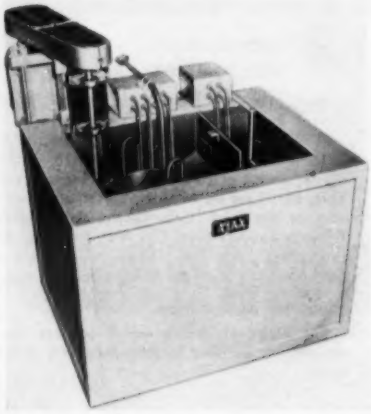
New gas analyzers for on-the-job determinations of carbon dioxide or oxygen in flue gases, furnace atmospheres and other mixtures has been announced by Burrell Corp. A rubber hand pump is connected to the source of the gas by rubber tubing. By a few squeezes, a sample is in the analyzer. A shake or two and a needle registers the percentage of carbon dioxide or oxygen present in the sample on a dial. Reproducible results are shown directly to ¼%.



For further information circle No. 1934 on literature request card on p. 36-B.

Quench Furnace

Ajax Electric Co. has announced the development of a new salt bath isothermal quenching furnace. The furnace features the uniform, high velocity downward flow of salt con-



fined within a special quench header. Cataract quenching increases the cooling rate in the critical range, 1300° F. to 1000° F., thus getting past the nose of the "S" curve. Any steel that can be satisfactorily hardened by oil quenching can now be either martempered or austempered in a cataract quench furnace.

For further information circle No. 1935 on literature request card on p. 36-B.

Surfactant

Swan Finch Oil Co. has announced a new surfactant, Swanite, which will function in most alkaline and acid solutions. It possesses the usual wetting, emulsifying, grease and oil removal and surface tension lowering properties. It is claimed that Swanite will not corrode or tarnish metals—it may be used with phosphoric acid to brighten aluminum. It can be used in cleaning formulas and plating solutions, and is low foaming.

For further information circle No. 1936 on literature request card on p. 36-B.

Control Unit Corrects Thickness Variations

A new automatic mill control unit that provides automatic correction of thickness variations in materials being rolled has been announced by Pratt & Whitney. The control unit can be mounted on the mill wherever convenient, with indicating meter on the operator's control panel. It may be used with any continuous mill gage and

with any electrically operated screwdown motor. The desired tolerances are set by means of potentiometers, and as soon as the gage registers an undersize or oversize, the control unit releases an electrical impulse to the screwdown motor or other control mechanism on the mill. This control motor is operated intermittently, allowing a time delay between each period for the correction to reach the gage. Duration of the correction is progressive, thus the further away from zero, the longer the duration of adjustment.

For further information circle No. 1937 on literature request card on p. 36-B.

Btu Recorder

Continuous measurement and control of rate-of-heat input or output is now possible with the new Dynamaster Btu recorder-controller systems announced by the Bristol Co. One Dynamaster measures the temperature difference with two resistance thermometer bulbs and receives the flow-rate from a flow transmitter. From the two variables, it then continuously computes and records the

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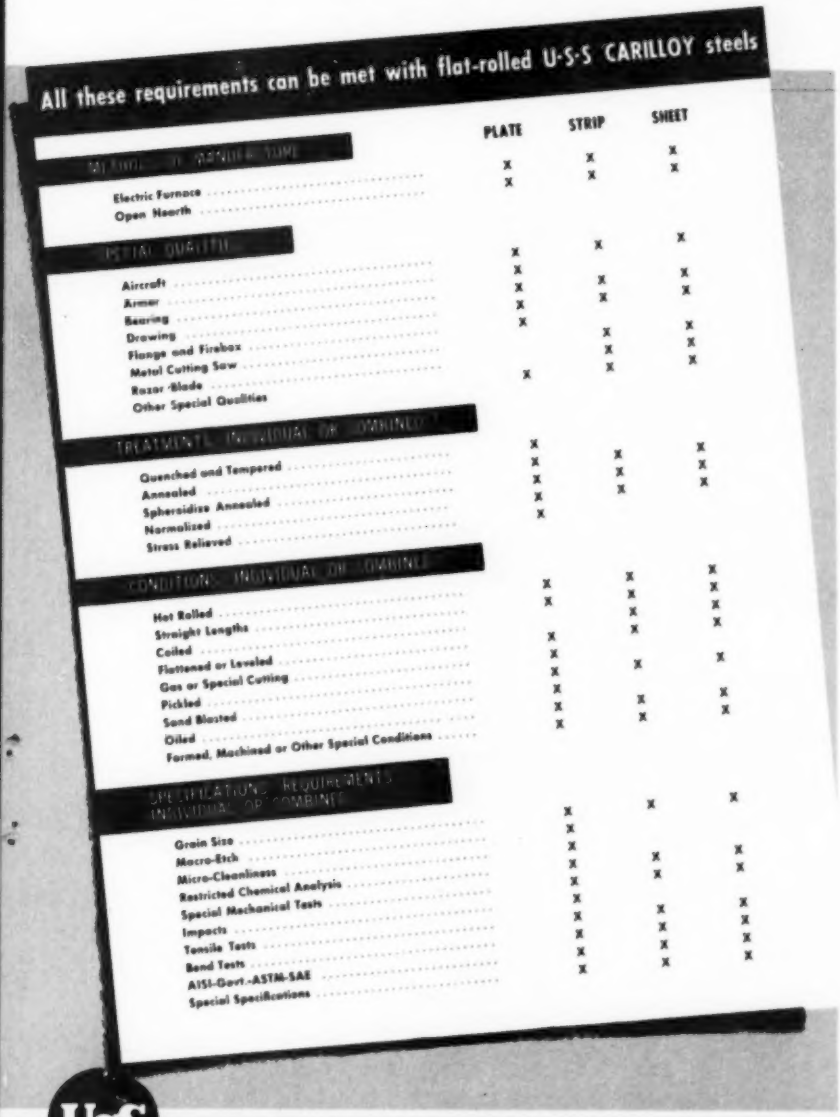

• Note the accompanying list of qualities, treatments, conditions and specification requirements that can be furnished in U·S·S Carilloy plate, sheet and strip. This is the widest selection of flat-rolled Alloy Steel products you can secure from any one producer. Our unmatched mill flexibility and size range enable you to order anything from a razor blade strip to a plate for a battleship. This streamlines your purchasing, assures consistent quality and simplifies your manufacturing problems.

For complete information, contact our nearest sales office, or write direct to United States Steel Corporation, Room 2819-Z, 525 William Penn Place, Pittsburgh 30, Pa.

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Any time you have a metallurgical or fabricating problem, call in a United States Steel Service Metallurgist. He has an extensive knowledge of all types of Alloy Steels and can help cut costs by offering suggestions to assist your engineering and production people.

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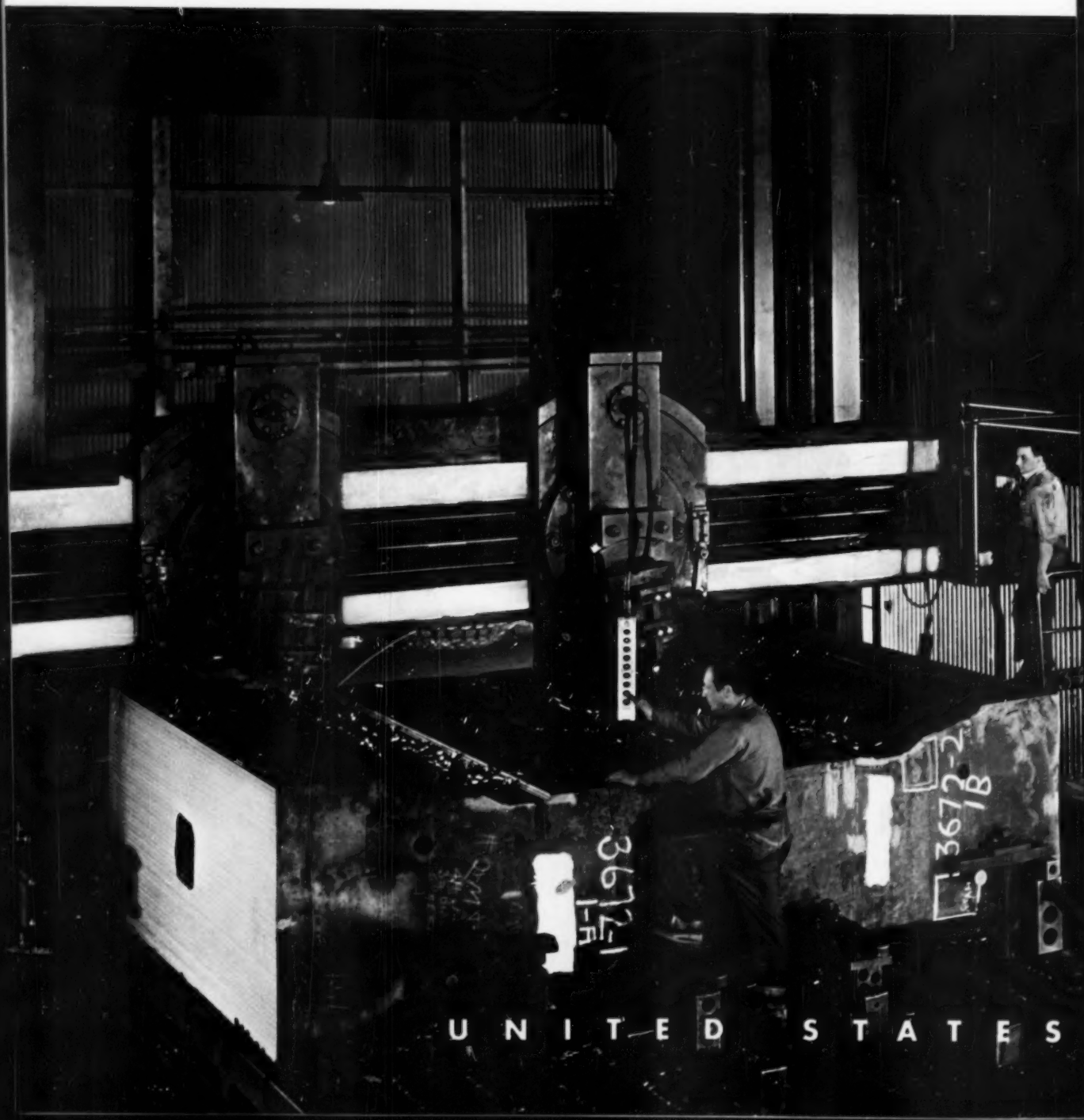
UNITED STATES STEEL

"We machine these forgings on the double"



UNITED STATES

says Frank W. Koch, U.S. Steel Machinist

IN a constant effort to save money and speed delivery for our customers, we commonly machine even large forgings two at a time. In the set-up shown here, 8 tools were used at one time (in four tool holders) to machine these forged hammer bases as fast as humanly possible without sacrificing quality in any way.

It takes an experienced machinist to do work like this. Frank Koch started as a USS Machinist's Helper in 1925, and he has been at the job ever since. He has been working the big planers, like the one in the picture, for 18 years. Some of the toughest machining problems in the book are old stuff to him. The young man on the right is Stanley Kiragis, a Machinist's Helper, following in Frank Koch's footsteps.

When you buy a USS Quality Forging, you can be sure that seasoned hands like Frank Koch will carefully nurse it through the shop. With "homemade" steel, and the finest equipment, they assure you of a quality job, delivered on time, every time. Write for our free 32-page booklet that describes these forgings. Address United States Steel, Room 4570, 525 William Penn Place, Pittsburgh 30, Pa.

USS *Quality*

Resistance to rugged operating conditions is provided by Refractory Concrete at this Y-connection in hot-blast main at the National Tube Division of United States Steel Corporation, McKeesport, Pa. Refractory Concrete provides smooth, jointless construction.

. . . A tough problem solved by refractory concrete

A hot-blast furnace main presents a tough refractory structural problem where the curved arches meet in a Y-intersection. How refractory concrete solves the problem is shown above. Repairs and maintenance were reduced, and time was saved both in installation and operation.

Such jobs call for a refractory that resists extreme conditions of abrasion and thermal shock. In an emergency, refractory concrete, made with Lumnite* calcium-aluminate cement, was tried. Result: a successful job, and refractory concrete is now commonly used for this purpose.

Refractory concrete may solve some of your refractory problems. It withstands temperature of 2600°F. or more, has low volume change, and is highly resistant to thermal shock.

FOR CONVENIENCE, you may prefer to make refractory concrete with prepared castables (packaged mixes of Lumnite Cement and aggregates selected for specific temperatures and insulation service—add only water). They are made by refractory manufacturers and sold through their dealers. For more information, write Lumnite Division, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

**"LUMNITE" is the registered trade-mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.*

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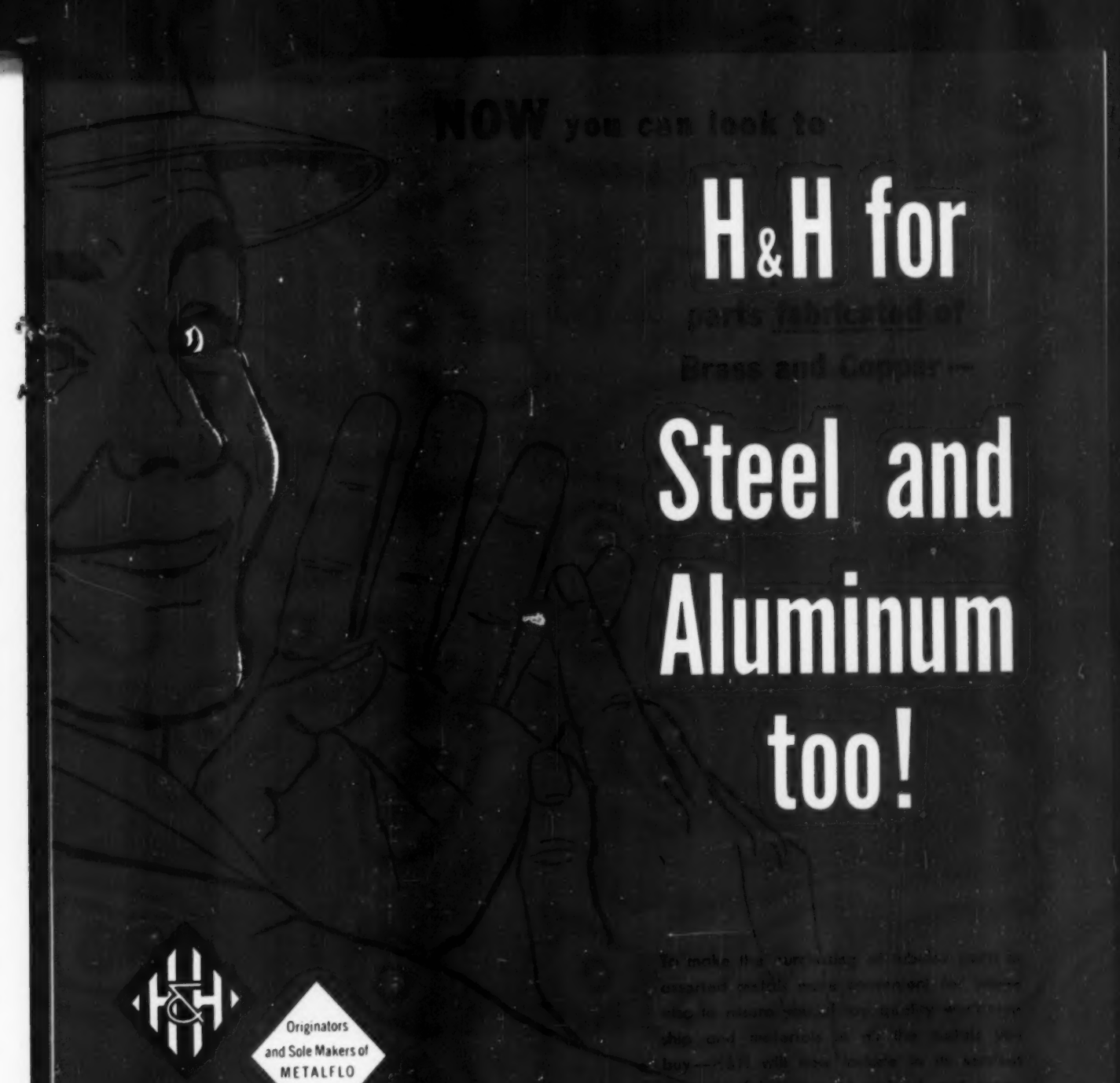

H&H for Steel and Aluminum too!

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H&H Tube
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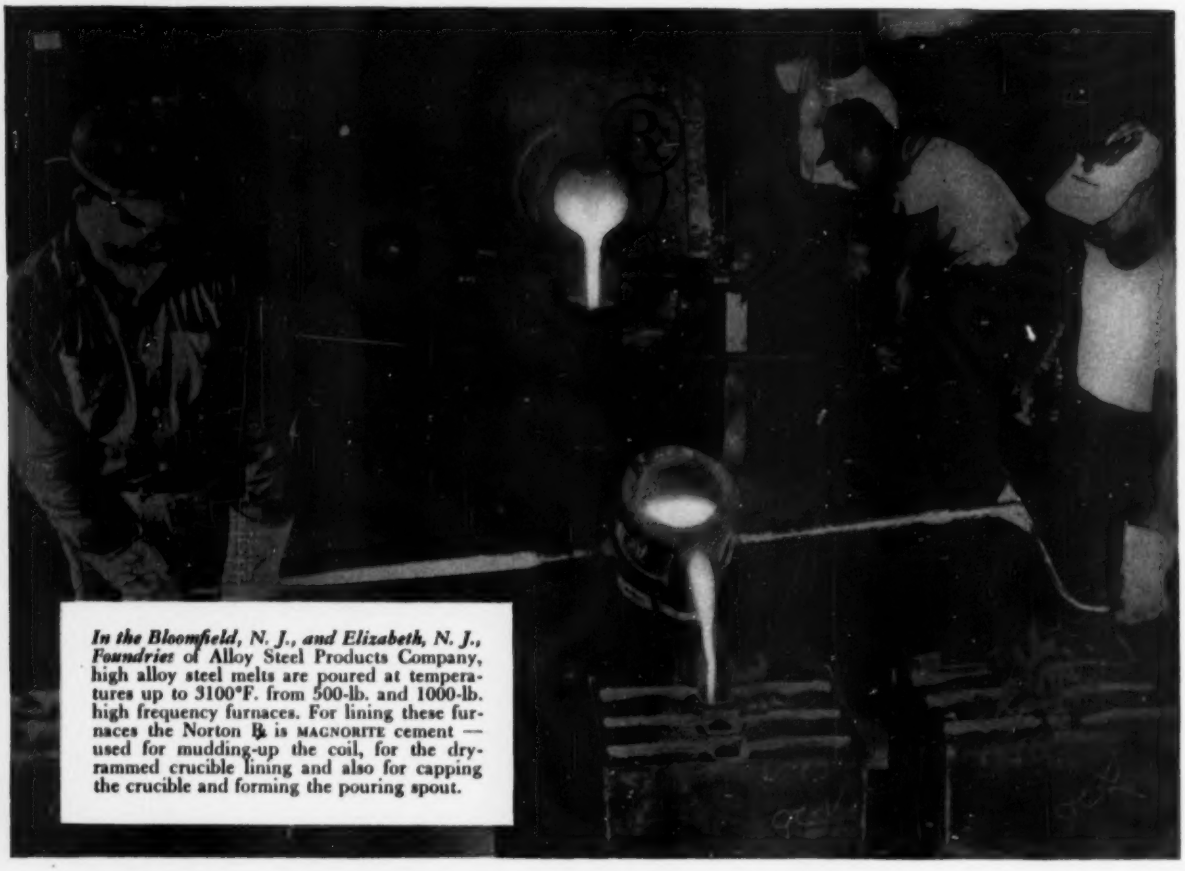
Another Norton Rx *on the job!*

*Makers of famous Aloyco Valves, after testing many cements, standardize on MAGNORITE**



In the Bloomfield, N. J., and Elizabeth, N. J., Foundries of Alloy Steel Products Company, high alloy steel melts are poured at temperatures up to 3100°F. from 500-lb. and 1000-lb. high frequency furnaces. For lining these furnaces the Norton Rx is MAGNORITE cement — used for mudding-up the coil, for the dry-rammed crucible lining and also for capping the crucible and forming the pouring spout.

Over the years the Alloy Steel Products Company, world's largest specialists in high alloy, corrosion resisting valves, have tested many refractory materials for the linings of their high frequency induction furnaces.

These tests proved that Norton MAGNORITE cement, engineered-to-the-job, lasted longer and performed better than any other material. As a result, Aloyco now uses MAGNORITE cement exclusively for lining these furnaces — still another example of how Norton refractories and refractory materials are *engineered and prescribed* to provide time-and-money-saving Rx's.

The Right Rx For YOU

For your own induction furnace operations, Norton will be glad to engineer MAGNORITE cement to your exact requirements. It withstands temperatures up to 3250°F. Its high-rammed density offers great resistance to metal penetration, erosion and chemical attack. And it is designed to expand slightly when sintered so that the crucible lining is free from shrinkage cracks that often lead to furnace failures. Why not run a test on one of your furnaces soon?

This engineering service applies, of course, to any metal-melting problem you may have. Working with MAGNORITE*, ALUNDUM*, CRYSTOLON* and fused stabilized zirconia cements and special shapes, Norton engineers are sure to come up with the right answers. For details, see your Norton Refractories Engineer, or write to NORTON COMPANY, Refractories Division, 331 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.

NORTON

REFRACTORIES

Engineered... Rx... Prescribed

Making better products... to make other products better

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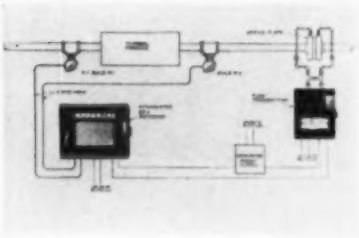
Btu product. Other systems provide for recording temperature difference along with Btu on a single round or

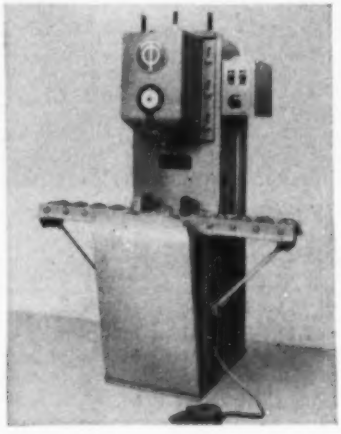


strip chart by a single two-pen recorder, showing Btu and either flow-rate or temperature difference by two separate instruments.

For further information circle No. 1938 on literature request card on p. 36-B.

Hardness Tester

Hardness test can be made at the rate of 10 or more specimens a minute with the new conveyorized Olsen automatic Brinell hardness tester. Designed for production line use, the tester has a built-in roller conveyor and air-operated lift which places each specimen, in turn, in test position. All operations are controlled by a foot



pedal. When positioned, a preset load, from 500 to 4000 kg., is applied to the specimen automatically by the steel ball and held for the period set on the electric timer. The operator watches the direct reading gage. Specimens meeting requirements are returned to the conveyor. Rejects can be removed from the tester quickly.

For further information circle No. 1939 on literature request card on p. 36-B.

Aluminum Cleaner

Enthone, Inc., has announced a new detergent for rapid cleaning of aluminum. This product is mildly alkaline, does not etch metals either at the air inter-face or in contact with other metals, and possesses high detergency. The cleaner is recommended for cast and wrought aluminum prior to anodizing, chromate treatments, organic finishing, resistance welding and plating by the non-etching process.

For further information circle No. 1940 on literature request card on p. 36-B.

Brazing

Typewriter parts are brazed on a high-production basis by using United Wire & Supply Co.'s brazing alloy

product. In brazing return bars, a special jig set-up, shown in the figure above, is used. Preplaced brazing rings furnish the brazing metal.

For further information circle No. 1941 on literature request card on p. 36-B.

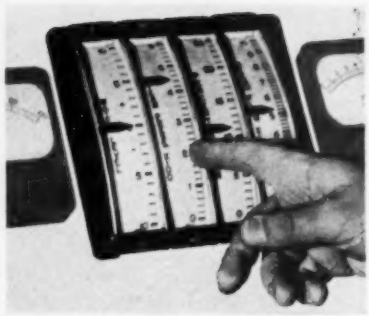
Ultrasonic Inspection

A new precision instrument simultaneously applying ultrasonics and digital automation to parts inspection as production line procedure has been announced by Sperry Products, Inc. It is being installed at Allison Div. of General Motors Corp. specifically for the inspection of jet engine rotor forgings and other unfinished engine parts. The instrument beams ultrasonic waves at a circular part mounted on a rotating turntable immersed in water. Beams reflected by structural discontinuities are logged on a circular chart. The complete installation comprises a scanning machine, recorder, control cabinet, and electronic console, which is also a monitoring station.

For further information circle No. 1942 on literature request card on p. 36-B.

Indicator

A miniature remote indicator which has a 5 in. useable scale has been announced by the Hays Corp. Special features are removable units, easy zero adjustment, no parallax, internal illumination, and flush or semi-flush panel mountings. Indicators can be supplied as an electric or pneumatic receiver for the measurement of any function such as pressure, draft, flow, level or temperature. The pneumatic type gage uses as its actuating element a spring-loaded metallic bellows with built-in overpressure protection.



The electric model uses a specially designed motor, electronic amplifier, and a pair of differential transformers forming an electric null balance circuit.

For further information circle No. 1943 on literature request card on p. 36-B.

Barrel Finishing

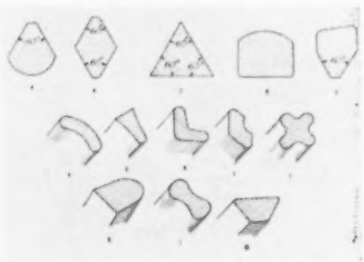
Almco Supersheen has announced a new model barrel finishing machine which is compact, simple to operate

and has finger-tip control. Variable speeds are from 12 to 50 r.p.m. The unit is of all-welded construction. Twin barrels are 8 x 16 in. It contains two loading and screening drawers.

For further information circle No. 1944 on literature request card on p. 36-B.

Formed Wire

Intricate formed wire shapes have been announced by Heli-Coil Corp. The accompanying illustration shows



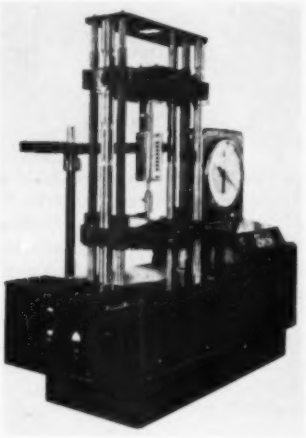
cross-sections which can be produced. Numerous variations of these forms can be made, as well as many other forms not shown. This wire is avail-

able in sizes ranging from a maximum section of 3/16 in. to a minimum of 0.015 in., and can be produced of stainless steel, phosphor bronze, Hastelloy C, music wire (0.75% C) and other metals.

For further information circle No. 1945 on literature request card on p. 36-B.

High Temperature Testing

Riehle Testing Machines Div. has announced a new universal testing machine for determining how metals will react during forming operations and in use at high temperatures. This testing machine can utilize electric

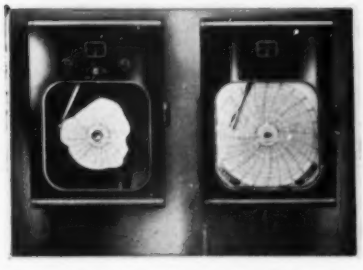


furnaces producing temperatures to 1750° F. Screw-powered, the machine provides positive control of testing speed and maintains a constant rate of strain at any speed setting. It accommodates specimen diameters of 0.252 to 0.505 in.

For further information circle No. 1946 on literature request card on p. 36-B.

Control of Test Cabinets

A complete line of control instruments for use with environmental test cabinets has been announced by Bristol. These instruments can be used to initiate and maintain an entire program of varying climatic conditions



within the test cabinet, and to simulate any desired temperature, humidity, or altitude conditions. The program controllers will carry through the program repeatedly and reproduceably. They can also be used to bring temperature, pressure, or vacuum up to any desired value and maintain it there for a predetermined length of time. Available with electric on-off or proportional-input control or with pneumatic control, the instruments can be adapted to any model test cabinet.

For further information circle No. 1947 on literature request card on p. 36-B.

Hardness Tester

An instrument that can make both regular and superficial Rockwell hardness tests has been announced by the Torsion Balance Co. It makes all regular Rockwell tests (60, 100 and 150 kg. loads) and superficial tests (15, 30 and 45 kg. loads) with any suitable standard C, N or ball-type indenter. Results show on a direct dial gage with a single numerical scale. Minor and major loads are applied by dead weights, not springs. Stops are inserted on the sides of the column for changes in test loads. The major load being used is indicated by the location of the stops. Controls such as the elevating-screw handwheel, gage-setting bezel, load-tripping and load-lifting mechanism are located in the front of the base.

For further information circle No. 1948 on literature request card on p. 36-B.

Vacuum Gage

A new vacuum gage has been announced by Naresco Equipment Corp. It operates in six ranges permitting the measurement of pressures from 1000 to 0.0001 mm. Hg on a linear scale. The gage uses a sealed radium source; this emits alpha particles and produces ionized gas molecules which are collected on a plate to produce a current indicating directly the measured pressure. The gage cannot be damaged by exposure to atmos-

pheric pressure because the ion source operates at room temperature and at zero potential.

For further information circle No. 1949 on literature request card on p. 36-B.

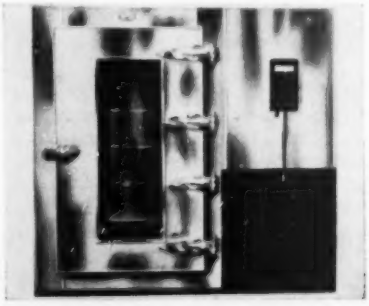
Conveyor

Alvey-Ferguson Co. has announced the installation of a conveyor for moving single 16 ft. flat steel sheets from the seam welder to the roll former. This wheel-type conveyor is an assembly consisting of nine rows of two units placed end to end, pitched slightly downward, spaced about 2 ft. apart, and mounted on center supports. The steel sheets move by gravity from one operation to the other, semi-automatically. These units are the lightest of all-steel portable wheel-type conveyors. They are available in 5 and 10 ft. lengths, straight or curved, single or assembled sections.

For further information circle No. 1950 on literature request card on p. 36-B.

Test Chamber

Webber Mfg. Co. announces a new chamber for large capacity testing at high and low temperatures. The unit illustrated has 30 cu. ft. capacity. It features a visible type controller, patented heat exchangers and visual port and apertures for connections to inner chamber. It is of stainless steel construction with fiberglas insulation. Temperature range is —40 to +200° F. Other units are available to temperatures of —200° F.



For further information circle No. 1951 on literature request card on p. 36-B.

Ultrasonic Cleaner

A new type of ultrasonic cleaner for small processed parts has been announced by Pioneer Central Div.

of Bendix Aviation Corp. The unit operates with either water-soluble detergents or cleaning solutions and features the lower-frequency, magnetostrictive transducer. The ultrasonic energy forces the solution to cavitate or "cold-boil", with countless minute bubbles. These bubbles implode and blast particles of grease, grit and other foreign matter loose, reaching inaccessible recesses of precision parts. The cleaning unit will be manufactured in diameters of 4, 7½ and 12 in., each with a depth equal to its diameter.

For further information circle No. 1952 on literature request card on p. 36-B.

Creep and Stress Rupture Testing

A new 12,000 lb. capacity creep testing machine for determining the stress required to rupture specimens as well as creep properties up to rupture has been announced by Riehle Testing Machines. A new ball-seated loading device insures that specimen holders are self-aligning. The specimen is accordingly freed from bending moments which give erroneous results. Other available equipment includes an electric furnace, a lever levelor, a hydraulic recoil absorber to prevent damage and noise, and a motorized elevator to lift the load from the beam.

For further information circle No. 1953 on literature request card on p. 36-B.

Surface Roughness Scales

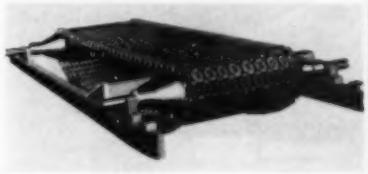
New cylindrical surface roughness scales, designed as a standard of comparison by sight and touch for internal and external curved surfaces, have been announced by the General Electric Co. Consisting of two scales each,

6 in. wide and 2 in. long, the set can be used for determining the roughness of surfaces produced by grinding, lapping, honing, superfinishing, turning, boring, drilling and others. Scale number one is capable of determining the surface roughness of 10 specific surfaces in the 4, 8, 16, 32 and 63 microinch categories. On scale number two, typical surfaces in the 16, 32, 63 and 250 microinch values are determined.

For further information circle No. 1954 on literature request card on p. 36-B.

Conveyor Belt

A belt conveyor of new design featuring an open-type link has just been announced by Standard Alloy Co. The new open-link design makes the belt readily adaptable to annealing, normalizing, stress relieving, and tempering furnaces where circulation



of the atmosphere in the furnace is essential. The belt conveyor is available in regular widths from 18 to 60 in., is adaptable to comparatively long spans and operates in temperatures of 1800° F.

For further information circle No. 2237 on literature request card on p. 36-B.

Controllers

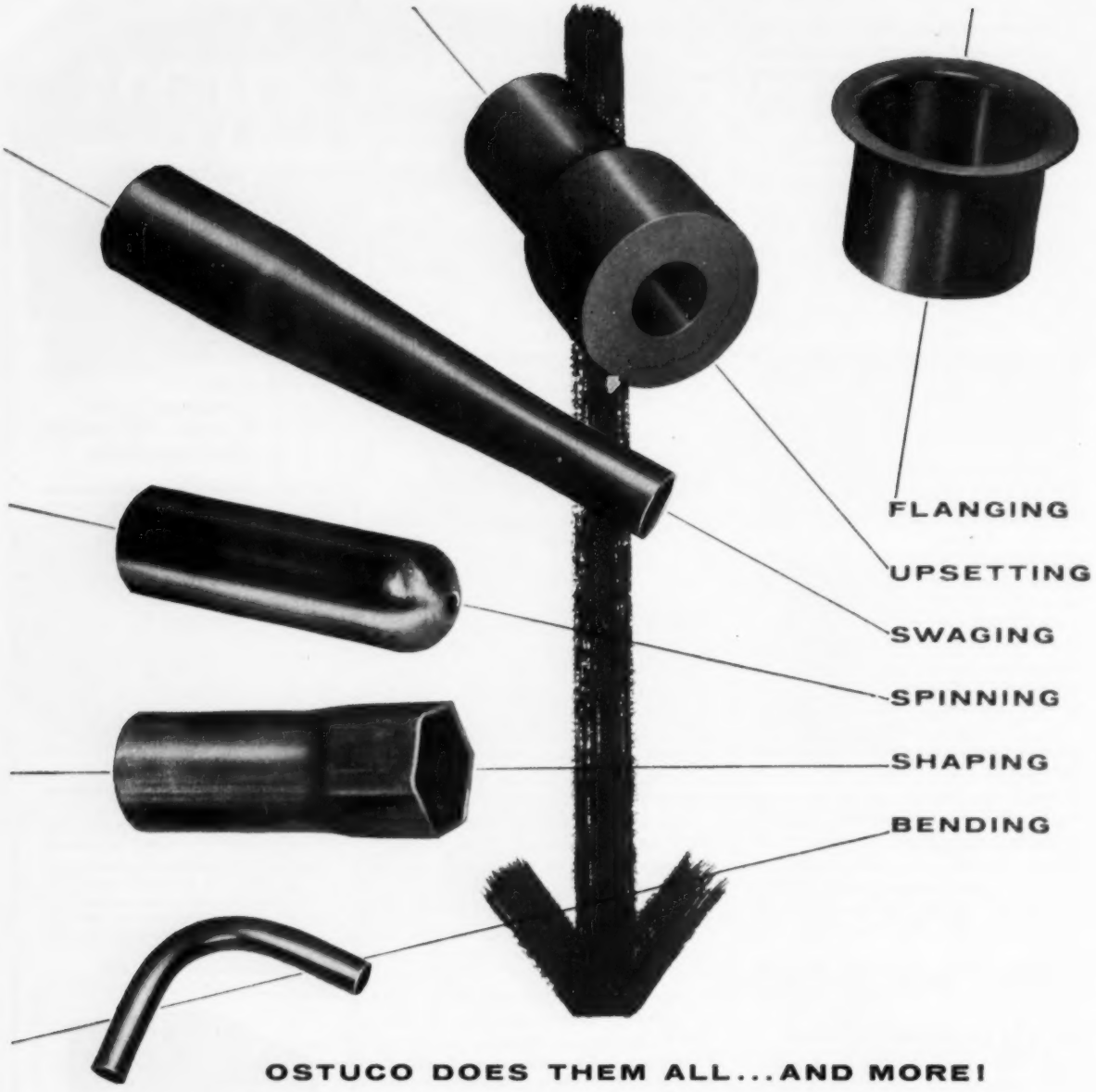
Program controllers which assure completely automatic process control of any time-temperature cycle with off-on, proportioning, high limit or stepless control action plus secondary control action have been announced by West Instrument Corp. Once the desired time-temperature for a given process has been determined, it can be repeated automatically, as frequently as may be desired.

For further information circle No. 2238 on literature request card on p. 36-B.

Thickness Tester

A magnetic thickness tester for determining the depth of electrodeposited hot dipped or painted coatings on steel and other magnetic metals has been announced by Gardner Laboratory, Inc. It is about the size of a fountain pen. Each gage is calibrated against National Bureau of Standards thickness plates. The gage is equipped with several magnets for use at different ranges of thickness. Accuracy is within 10% at 0.0002 in.

For further information circle No. 2239 on literature request card on p. 36-B.



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CANADA, RAILWAY & POWER CORP., LTD.
EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY
117 Liberty Street, New York 6, New York

1955. Abrasion Tester
Bulletins on durable precision instrument for evaluating the resistance of surfaces to rubbing abrasion. *Taber Instrument*

1956. Alloy Castings
22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

1957. Alloy Castings
Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

1958. Alloy Chart
Comparison of AISI, SAE, ACI, AMS, WAD and PWA chromium and chromium-nickel stainless specifications. *Cannon-Muskegon*

1959. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

1960. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

1961. Alloy Tools
44-page book on cast Stellite tools for metal cutting. *Haynes Stellite*

1962. Aluminum Cleaning
48-page booklet gives practical tips on materials and methods of cleaning aluminum and magnesium. *Oakite*

1963. Aluminum Coating
Article on hot dip coating of ferrous metals with aluminum and aluminum alloys from "Tips and Trends." *Ajax Electric*

1964. Aluminum Forgings
Folder on advantages of forgings in many applications. *Bridgeport Brass*

1965. Analysis of Nickel Alloys
52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys." *International Nickel*

1966. Annealing Furnaces
8-page illustrated booklet on continuous annealing furnaces. Schematic diagrams, photographs, and actual production data. *Drever*

1967. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

1968. Atmosphere Furnace
Information on mechanized batchtype atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1969. Atmosphere Furnace
Reprint on bright annealing of copper in atmosphere furnace. *Holcroft*

1970. Atmospheres
12-page booklet on design and use of special atmospheres for industrial furnaces. *Continental Industrial Engineers*

1971. Barrel Finishing
32-page handbook on compounds for descaling, deburring, coloring, metal cleaning, rust inhibition. *Lord Chemical*

1972. Bearings
27-page bulletin, S-53, on self-lubricating bronze bearings, core and bar stock. *Amplex Division*

1973. Bending
Catalog on presses for bending, forming, blanking, drawing and multi-punching. *Cleveland Crane & Engineering*

1974. Bending and Cutting
Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

1975. Beryllium Nickel
4-page leaflet on high-strength, corrosion-resistant beryllium nickel casting alloys. *Beryllium Corp.*

1976. Bimetal Applications
36-page booklet, "Successful Applications of Thermostatic Bimetal," describes 22 uses and gives engineering data. *W. M. Chace*

1977. Black Oxide Finish
Folder on penetrating black finish for ferrous metal. *Puritan Mfg.*

1978. Blackening Copper
Bulletin of operating instructions for blackening and coloring copper and copper alloys. *Enthone*

1979. Blackening Stainless
Bulletin on process for blackening stainless steels, cast and malleable irons. *Mitchell-Bradford*

1980. Blast Cleaning
New 16-page bulletin on specifications and dimensions for Blastmaster barrels of many sizes. *Pangborn Corp.*

1981. Boron Additive
6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

1982. Brass Tubing
Bulletin on seamless, brazed and lock-seam tubing in brass and copper. *H & H Tube and Mfg.*

1983. Brass Wire
Folder shows extrusion, annealing and drawing of brass wire. Tempers, properties, tolerances. *Titan Metal*

1984. Brazing
Bulletin 5889 on furnace and induction brazing installations and methods. *General Electric*

1985. Bright Dip Coating
Data on cold bright dip coatings for zinc. Procedures, solution concentrations, analysis and control. *Chemical Corp.*

1986. Bronze Bearings
New brochure on bearing bronze. *American Smelting and Refining Co.*

1987. Burners
16-page bulletin on selection of gas burners. *Western Products*

1988. Burners
8-page reprint No. 43 on Method for Improving Temperature Uniformity in Furnaces. *North American Mfg.*

1989. Bushings
Catalog of half-bushings and sleeves made of Haynes heat and abrasion resistant alloys. *Haynes Stellite*

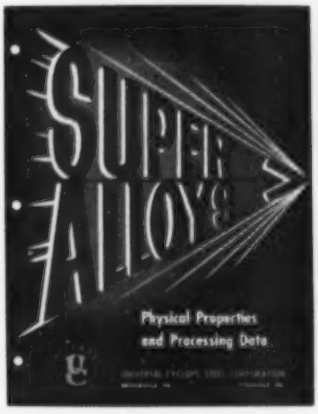
1990. Carbides
4-page folder on die grades of cemented carbides for drawing, blanking, forming, heading, notching, piercing, punching. *Kennametal*

1991. Carbon and Graphite
20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical, process fields. *National Carbon*

1992. Carbon Brick
Bulletin on properties, grades, applications of carbon and graphite brick for handling corrosive chemicals and molten metals. *National Carbon*

2236. Alloys for High Temperatures

This 29-page booklet is concerned with analyses and properties of high temperature alloys. Diagrams compare several superalloys with carbon steel as to yield strength, tensile



strength, stress-rupture and creep properties at various temperatures. Tables give chemistry and physical properties of ferritic and austenitic superalloys. *Universal-Cyclops Steel Corp.*

1993. Carbon Control
Catalog T-623 describes the Microcarb control system that continuously measures the active carbon in the furnace atmosphere during heat treatment. *Leeds & Northrup*

1994. Carbonitriding
28-page booklet on nature of process, furnaces, atmospheres, parts carbonitrided and properties. *Armour Ammonia*

1995. Carbonitriding
Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

1996. Castings
4-page folder on specialty carbon and alloy steel castings. *Farrell-Cheek Steel Co.*

1997. Centrifugal Castings
Folder on centrifugal castings of heat, corrosion and abrasion resistant alloys, nonferrous metals, carbon and low alloy steels. *Sandusky Foundry & Machine*

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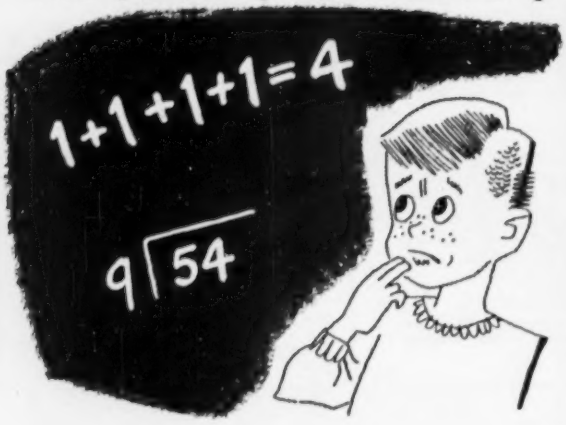

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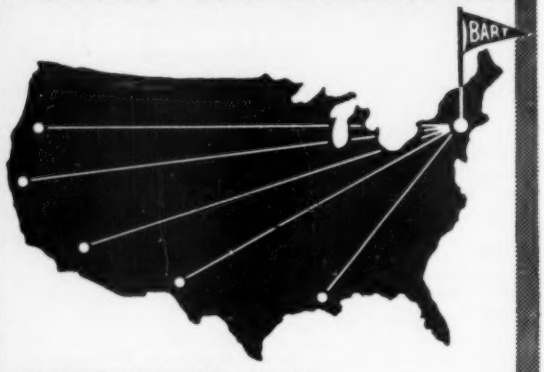

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1998. Chromate Coatings
Folder gives characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research*

1999. Chromium Cast Iron
48-page book on effects of chromium on properties of cast iron. Data on production and uses. *Electro Metallurgical*

2000. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

2001. Cleaners
Folder on immersion, electrolytic, spray cleaners, phosphate coaters, strippers, drawing compounds, additive agents. *Northwest Chemical*

2002. Cleaning
28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

2003. Cleaning Stainless
8-page booklet on care and cleaning of stainless steels. *Republic Steel*

2004. Coil Splicer
Bulletin 43 on automatic welding coiled material end to end. *E. W. Bliss*

2005. Compressors
12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

2006. Controllers
Data sheets on indicating pyrometric controllers, proportioning controllers, portable controllers, pyrometer accessories. *West Instrument*

2007. Copper
Report on supply of copper, mine production, scrap utilization, importation, reserves. *Copper & Brass Research Assoc.*

2008. Copper Alloys
64-page book on free-cutting brass, copper and bronze. *Chase Brass*

2009. Copper Alloys
New 48-page book contains tables of alloys with composition, typical uses, general, working, mechanical, electrical properties, hardness, ASTM specification numbers. *Revere*

2010. Corrosion Data
Bulletin gives comparative resistance to various corrosive media of several stainless steels. *Babcock & Wilcox*

2011. Corrosion of Copper
28-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tabulation of their relative corrosion resistance. *American Brass*

2012. Corrosion Resistance
35-page booklet on plastic materials of construction. *Atlas Mineral Products*

2013. Cut-Off Wheels
Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

2014. Cut-Off Wheels
36-page revised manual on cut off machines and abrasive wheels. *Norton Co.*

2015. Cutting
New bulletin on cutting torches, one using acetylene and the other propane. *Universal Cutting & Welding Equipment*

2016. Cutting Oil
Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

2017. Cutting Oil
Folder on sulphurized cutting fluid for a wide range of machining jobs. *Gulf Oil*

2018. Definitions
36-page glossary of over 150 terms on cast iron. *International Nickel*

2019. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

2020. Degreasing
40-page book on properties and use of trichlorethylene. Methods of handling and safety measures. *Niagara Alkali*

2021. Descaling
Brochure on sodium hydride descaling, its uses, advantages, typical reactions and necessary equipment. *Ethyl Corp.*

2022. Descaling
Bulletin on new machines for descaling steel sheets, plates and coils after hot rolling or heat treating. *Pangborn Corp.*

2023. Dew-Point Recorder
Bulletin 407 and Data Sheet AED 340-7 on dew-point systems for recording or controlling. *Foxboro*

2024. Die-Casting Machines
Copies of "Lester Press" describe various features of aluminum die casting machines. *Lester-Phoenix, Inc.*

2025. Die-Casting Machines
Case histories of companies using various types of die-casting machines. *Kux Machine*

2026. Die Castings
28-page booklet on die casting process and application of die castings. *American Zinc Institute*

2027. Die Steel
Bulletins on air-hardening, high-carbon, high-chromium die steel containing sulphide additives. *Latrobe*

2028. Ductile Iron
3-page bulletin on wear properties of ductile iron gears, bearings and dies. *International Nickel*

2029. Electric Furnace
Bulletin on box-type, pre-heat and hardening furnace with automatic atmosphere contamination control. *Pacific Scientific*

2030. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

2031. Electroplating
16-page booklet on methods and equipment for electroplating. Also machinery for cleaning, pickling. Control equipment. *U. S. Galvanizing & Plating Equipment.*

2032. Electroplating
New bulletin on electroplating lists key characteristics of 16 processes. *Hanson-Van Winkle-Munning*

2033. Extrusion Presses
8-page bulletin on presses designed for extrusion of aluminum, brass and other nonferrous metals. *Lake Erie Engineering*

2034. Extrusions
12-page circular on aluminum extrusion process contains selection data. Process described. Advantages. *Precision Extrusions*

2035. Fatigue of Magnesium
18-page paper, "Plastic Flow and Work Hardening Phenomena in Magnesium Alloys During Fixed-Deflection Fatigue Tests." *Dow Chemical*

2036. Filters
16-page bulletin on pressure filters and their accessories. *Permutit Co.*

2037. Filters
8-page bulletin on dimensions and capacities of industrial filters. *Industrial Filtration Co.*

2038. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

2039. Finishing
Catalog A-654 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

2040. Flow Meters
Catalog 2320 on indicating, recording integrating and controlling flow meters. *Minneapolis-Honeywell*

2041. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g.*

2042. Forgings
16-page brochure on steel drop, upset and press forgings. *Amforge Div., American Brake Shoe*

2043. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

2044. Forgings
Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U.S. Steel*

2045. Foundry Coatings
Data on colloidal graphite for mold washes, pattern coatings, core coatings, chill coatings. *Acheson Colloids*

2046. Freezer
Data on chest for use down to −95° F. for production use and testing. *Revco*

2047. Fuel-Air Controller
Data sheets on electric and pneumatic fuel-air ratio controllers. *Leeds & Northrup*

2048. Furnace
Bulletin on Karbo-matic furnace for carbonitriding, dry cyaniding or automatic hardening. *Pacific Scientific*

2049. Furnace Arches
Bulletin on sectionally suspended circular arches for rotary hearth furnaces. *Geo. P. Reintjes*

2050. Furnace Charging
12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

2051. Furnace Controls
44-page condensed catalog of controls for industrial furnaces and ovens. *Minneapolis-Honeywell Regulator Co.*

2052. Furnace Controls
22-page booklet on instruments and controls for heat treating furnaces. *Hays Corp.*

2053. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

2054. Furnaces
32-page catalog of heat treating and forging furnaces, blowers, melting furnaces, control equipment and accessories. *Johnson Gas Appliance*

2055. Furnaces
Catalog of gas or oil fired heat treating and melting furnaces. Conveyor type, pot furnaces, atmosphere furnaces. *Barkling Fuel Engineering*

2056. Furnaces
Bulletin on controlled atmosphere furnaces and generating assemblies for annealing, brazing, hardening, sintering, soldering. *Sargeant & Wilbur, Inc.*

2057. Furnaces
12-page brochure on car furnaces of special and conventional design. *Jet Combustion*

2058. Furnaces
Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000° F. *Harper Electric Furnace*

2059. Furnaces
High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

2060. Furnaces
Series of bulletins on controlled atmosphere, carburizing, nitriding, hardening furnaces. *American Gas Furnace*

2061. Furnaces
Folder on recuperative atmosphere furnaces for operation to 2500° F. *Lithium Corp.*

2062. Furnaces
Data on electric furnaces of top or side loading types. *Lucifer Furnaces*

2063. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

2064. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

2065. Furnaces, Heat Treating
Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

2066. Furnaces, Heat Treating
Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

2067. Gages
Data sheets on vacuum gages, direct reading, continuous measurement, control circuits. *Consolidated Vacuum*

2068. Gas Analysis
Bulletin on gas analyzer based on principle of thermal conductivity. *Charles Engelhard*

2069. Gas Generator
Bulletin G-16A on gas-fired and electric endothermic generators. Specifications. *Ipsen Industries*

2070. Gas-Oil Burner
Bulletin on closed flame gas-oil burners gives operation, capacities, dimensions. *Eclipse Fuel Engineering*

2071. Gold Plating
Folder on salts for bright gold plating. Also lists equipment needed. *Sel-Rex*

2072. Gold Plating
Article on analysis of gold and gold alloy plating solutions gives all currently available procedures. *Technic*

2073. Graphite Electrodes
16-page book on improved standards of electrode performance shows good and bad practice. *Great Lakes Carbon*

2074. Graphitic Tool Steels
48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

2075. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

2076. Hard Surfacing Alloy
Chemical and physical data on chromium, nickel, cobalt, molybdenum alloy as hard surfacing wire or in cast form. *Coast Metals*

2077. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

2078. Hardness Tester
Circular on portable hardness tester in sizes for work 1 to 6 inches round and flat. *Ames Precision*

2079. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

2080. Hardness Tester
Bulletin RH-12-54 on portable hardness tester for Rockwell readings. *Riehle*

2081. Hardness Testers
20-page bulletin on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument*

2082. Hardness Testing
8-page catalog B-953 on principles and standards of Brinell hardness testing, and types of machines. *Steel City Testing Machines*

2083. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

2084. Heat Treating
Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and

factual data on steel specifications, heat treatments, etc. *Sunbeam*

2085. Heat Treating
Bulletin 850 on shaker-hearth furnace for bright carburizing, carbonitriding, hardening. *Hevi Duty Electric*

2986. Heat Treating
Data on how to heat, quench, wash and temper automatically. *Metalwash Machinery*

2087. Heat Treating Baskets
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex Mfg.*

2088. Heat Treating Belts
Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

2089. Heat Treating Compound
Data on dry powder coating for promoting smooth heat treated parts. *Parker Stamp Works*

2090. Heat Treating Costs
Sample form recommended by Committee of Heat Treating for computing cost of heat treating. *ASM*

2091. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

2092. Heat Treating Guide
Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

2093. Heat Treating Stainless
84-page book on heat treating stainless steels, both martensitic and austenitic. *Republic Steel*

2094. Heat Treatment
Bulletin 200 on car hearth, rotary hearth, pit, roller hearth, belt, chain, pusher and "hi-head" furnaces. *R-S Furnace*

2095. Heliarc Welding
Pocket-sized folder contains current ranges and sizes for electrodes with table on current and number of passes required to weld various metals. *Linde*

2096. High-Alloy Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

2097. High-Speed Steel
Bulletin on structure and properties of "desegatized" high speed tool steel. *Latrobe*

2098. High-Strength Bronze
12-page booklet on telnic bronze with high strength, high hardness, good machinability, age hardenability, corrosion resistance. *Chase Brass*

2099. High-Temperature Alloy
Folder on NA22H, new high temperature alloy. *Blaw-Knox*

2100. High-Temperature Belts
New bulletin on belts of high-temperature alloy for heat treat furnaces. *Electro-Alloys Div.*

2101. High-Tensile Steel
Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

2102. Identifying Stainless
Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*

2103. Indicating Controller
Bulletin F-6314 on Series 400 Capacitrols for indicating and controlling temperatures, voltages, current, speed and similar variables. *Wheelco*

2104. Indicator
Folder on frictionless galvanometer. *Chas. Engelhard*

2105. Indicator
Bulletin on self-balancing indicators—potentiometer pyrometer and resistance thermometer. *Thermo Electric*

2106. Induction Heating
Book contains selector chart and heating and melting speeds for induction equipment. *Ajax Electrothermic*

2107. Induction Heating
60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

2108. Induction Heating
A new 8-page bulletin on forging with induction heat includes case histories, benefits to the forging industry. *General Electric*

2109. Industrial Fans
Catalogs on various kinds of industrial fans—exhaust, multiblade, backward curve, for high temperatures. *Garden City Fan*

2110. Instruments
New 12-page catalog of process instruments for measuring and controlling variables. Flow meters, pressure instruments, temperature, viscosity instruments. Recorders, controllers. *Fischer & Porter*

2111. Laboratory Furnaces
Information and bulletins available along with current price lists on complete assortment of Lindberg laboratory furnaces. *Boder Scientific Co.*

2112. Laboratory Furnaces
26-page, "Construction of Laboratory Furnaces," contains many diagrams, charts, tables and information on how to construct furnaces. *Norton*

2113. Laboratory Ovens
Catalog 331A on new models of laboratory ovens. *Precision Scientific Co.*

2114. Laboratory Ovens
New 8-page catalog of gravity and mechanical convection laboratory ovens. *Modern Laboratory Equipment Co.*

2115. Laminated Sheet
12-page bulletin on bonding plastic film and sheeting to metal. *Naugatuck Chemical*

2116. Leaded Steel
New bulletin on faster machining leaded alloy steel (0.40% C). *Ryerson*

2117. Leaded Steel
Folder gives advantages of leaded alloys. Case histories. *A. M. Castle*

2118. Leaded Steel
Bulletin on analysis and advantages of cold finished leaded steel bars. *LaSalle Steel*

2119. Low-Melting Alloys
Booklet on alloys for aluminum matchplates for core box and dryer patterns, for metallizing wood patterns and core boxes. *Cerro de Pasco*

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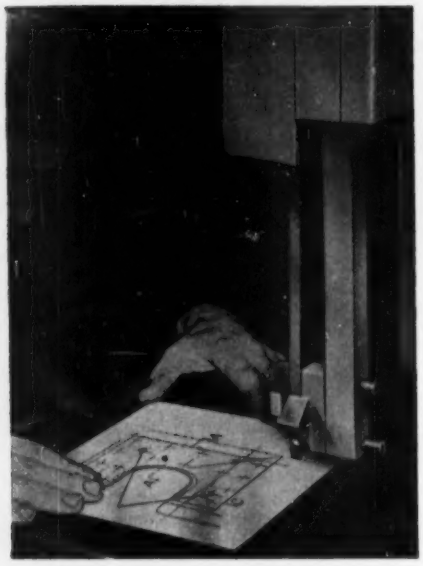
Many applications of low-temperature brazing illustrated and described. *Handy & Harman*

2121. Low-Temperature Properties
Article on application of extreme low temperatures to metallurgy. Behavior of metals at low temperatures. *Arthur D. Little*

Why Moly alloy steels are in your future

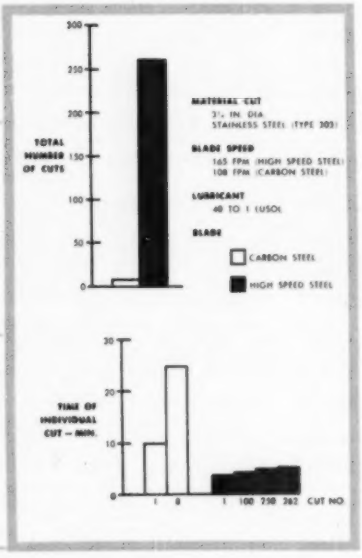


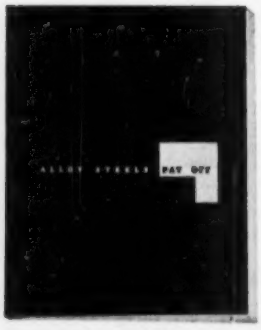
CUTTING LIFE INCREASED 10 TIMES

with

Moly tool steels

the part	**BAND SAWS**
the problem	Carbon-steel band-saw blades are usually made of a tool steel with about 1.25% C. For normal usage band saws make smoother and straighter cuts than hack saws. However, normal band saws run into difficulties when they're used as cut-off saws for materials with different machining properties.
the pay-off	The Henry G. Thompson & Son Company developed a moly high-speed steel, cut-off band-saw blade for stainless steel and other materials on a production basis. The chart shows graphically the results: cutting life of saw increased, time per cut shortened.





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Recent developments, factors affecting plating techniques, recommended procedures, in "Technical Advisor" No. 23. *Reynolds Metals*

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56-page Users' Manual and Buyers' Guide. Specifications, prices, thermocouple calibration data. *Bristol Co.*

(*Continued on p. 36-A*)

(Continued from p. 35)

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Data on salt bath furnaces for batch and conveyorized work. *Upton*

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75-page manual on salt baths for case hardening and heat treating. *DuPont*

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Handbook E-4 on resistance welded steel tubing. *Ohio Seamless Tube*

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Data on properties and uses of 95% tungsten alloy, balance nickel and copper. *Firth Sterling*

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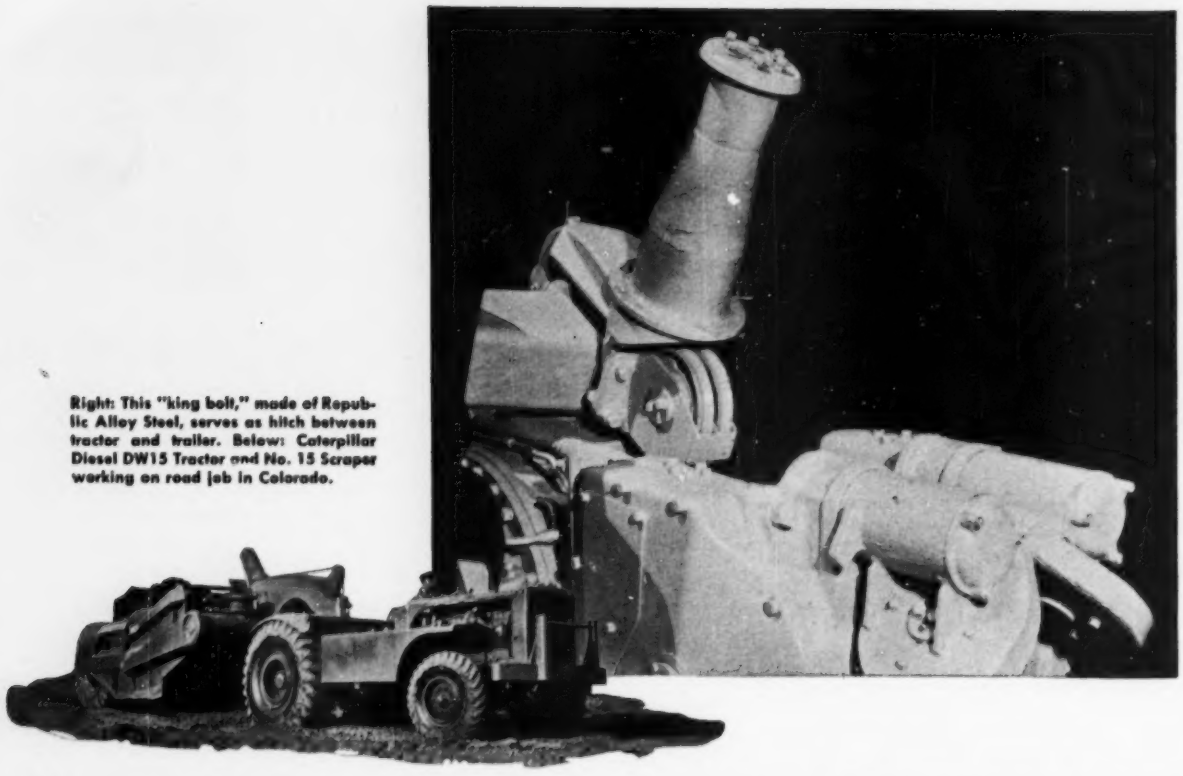

Right: This "king bolt," made of Republic Alloy Steel, serves as hitch between tractor and trailer. Below: Caterpillar Diesel DW15 Tractor and No. 15 Scraper working on road job in Colorado.

How Republic Alloy Steels Help CATERPILLAR®

Take the "king bolt." It's the link between tractor and scraper or wagon. It takes all the pull, the bumps, and the shocks when a tractor drags earth-moving or other heavy equipment over uneven ground. It has to be tough.

Caterpillar uses a specific Republic Alloy Steel for this part on its DW15 tractor. And for other parts as well, many of which are not as easy to spot. But all of which are important.

Republic has been supplying Caterpillar with alloy steels for a good portion of the 50 years that track-type machines have been roaming and moving the earth. More than this, Republic metallurgists have helped Caterpillar use these steels to best advantage.

This year is Caterpillar's 50th Anniversary in the manufacture of crawler tractors. And Republic is glad to congratulate a pioneer. You see, Republic pioneered the wide use of alloy steels. And we're still helping manufacturers use these steels profitably.

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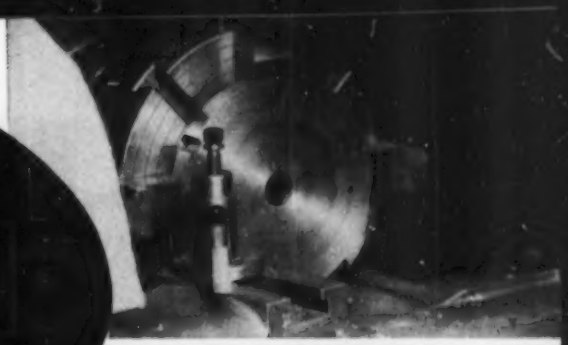
REPUBLIC ALLOY STEELS

Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Bars, Wire, Pig Iron, Steel and Plastic Pipe, Bolts and Nuts, Tubing

for these parts at
Pittsburgh-Erie Saw Corp . . .

"Latrobe FM Steel a must"



Photographs Courtesy of Pittsburgh-Erie Saw Corp.

Tool life increased 40% when machining Latrobe's "Free-Machining" BR-4 FM at Pittsburgh plant.

Pittsburgh-Erie Saw Corp., Pittsburgh, Pa., reports . . . "Because of the greater ease of machining BR-4 FM, we are reducing our production costs and especially increasing our drill life. Savings in production time combined with greatly increased tool life makes Latrobe's FM steel a must."

Pittsburgh-Erie's experience is another example of the cost-saving benefits derived from using Latrobe's "Free-Machining" FM high alloy tool steels. These FM steels—high carbon-high chromium die steels with sulphide additives evenly distributed as a result of the "Desegatized" process—consistently result in improved machinability, better machined surfaces and production economy through savings in time, labor and tool life.

Results of Specially Conducted Test by Pittsburgh-Erie

Under the same production conditions, the performance of Latrobe's BR-4 FM die steel (with sulphide additives) was compared to that of a regular high carbon-high chromium die steel of similar analysis and hardness.

ROUGHING CUT

	OTHER STEEL	BR-4 FM
Speed	180 RPM	392 RPM
Feed	.014 in.	.024 in.
Depth of Cut	1/8 in.	1/8 in.

FINISHING CUT

Speed	180 RPM	392 RPM
Feed	.014 in.	.010 in.
Depth of Cut	.015 in.	.015 in.

DRILLING TIME

Hole Size 1/8" Plate Thickness 3/4" Hand Feed

BR-4 FM—23 seconds per plate per one hole.
Other Steel—45 seconds per plate per one hole.

Latrobe
STEEL COMPANY
LATROBE, PENNSYLVANIA

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LATROBE STEEL CO., MP-2
LATROBE, PA.
Please send me data on FM steels.

NAME.....

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Gives short radiant tube long life with wrought Inconel

Short intense combustion is developed in this Inconel radiant tube. It's the "dimples" that do it. They set up tiny turbulent centers that mix the rich central gas stream with the inspirated surrounding air to promote fast burning and so reduce tube length. Inconel successfully resists the high temperatures produced in this new Lindberg development.

Lindberg Engineering saves weight and simplifies production, too

Here's a unique new Lindberg-designed radiant tube made of Inconel®.

It's short. It's straight. It's light. It transfers heat in a hurry. It has a remarkably long service life. It's fundamental to the design of Lindberg's new atmosphere hardening furnace . . . first tool-room-sized unit ever to be heated with gas-fired radiant tubes.

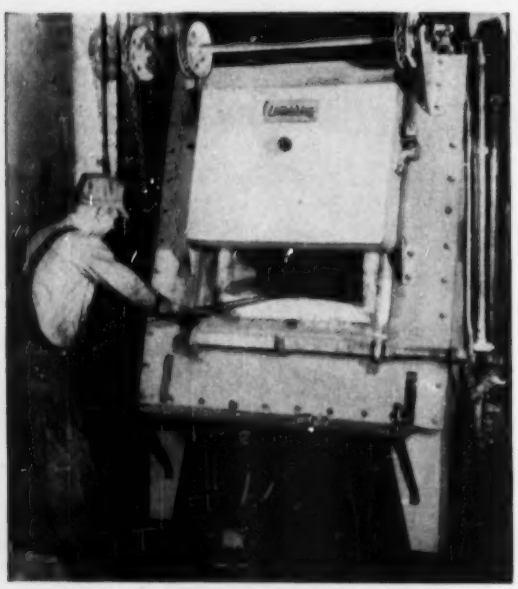
What the new tube does, is to develop as much combustion as in a standard long tube . . . but develop it in shorter time and hence, shorter length.

What Inconel does, is to provide within a light, thin-wall tube the strength and heat resistance needed to contain this short, intense combustion. Inconel also contributes rapid heat transfer properties and lends itself well to production by conventional methods.

For instance, the seamless Inconel tube is easily "dimpled" (to shorten and intensify combustion) about one-inch deep on six-inch off-set centers along the tube.

What wrought Inconel contributes to Lindberg's unique new radiant tube, it contributes to heat treating fixtures made by many other fabricators . . . built-in long life, strength and corrosion resistance at high temperatures and in most furnace atmospheres; excellent fabricating characteristics.

So, if these are qualities you need, look to Inconel. You can get more information on this useful Inco-Nickel Alloy in the Inco booklet, "Keeping Costs Down . . . as temperatures go up." Write for it, today.



First tool-room sized radiant-tube box furnace. The new *short* Inconel radiant tubes make it practical. Because the tubes are short, space-saving vertical mounting along the sides of the furnace is possible. Because they are made of high hot-strength Inconel, tubes are thin and lightweight, transfer heat rapidly, give long trouble-free life.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

Inconel

INCO TRADE MARK **NICKEL ALLOYS**

. . . for long life at high temperatures

What's Behind This Cutting Oil Picture?

Behind this cutting oil picture there's a story well worth telling . . . a story of 10 years' operation of the M. O. Devers Screw Machine Products Company.

During this time Devers has acquired and maintained a reputation for turning out the very highest quality precision machined parts and turning them out on time.

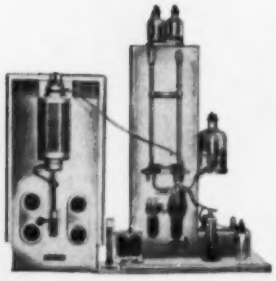
And during this same period, the oil that has helped Devers to achieve this enviable record is Cities Service Chillo #10 Cutting Oil. This one unusual oil has been used for work covering 1018, 1020, 4140, and stainless steel, and, says Devers official Harry E. McDaniel, "We have found it superior for <u>all</u> these machining operations."

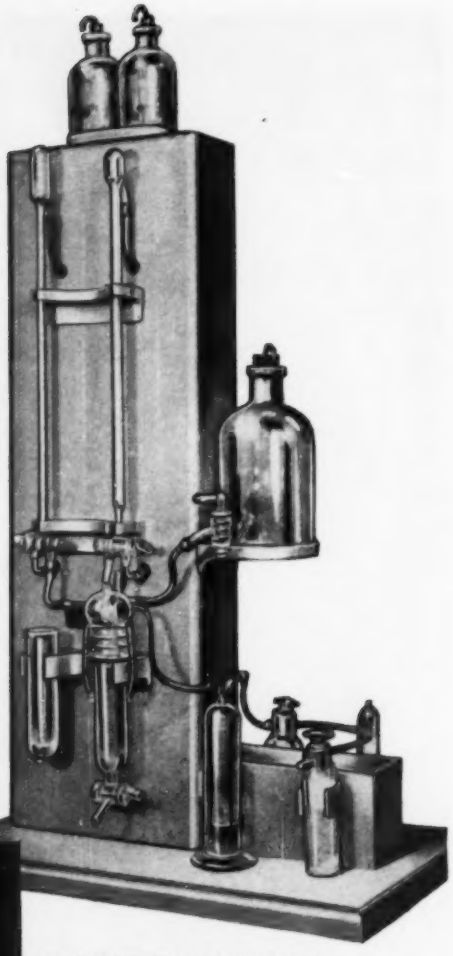
For longer tool life, closer tolerances, and a simpler cutting operation, you—like the M. O. Devers Company—will find it profitable to investigate Cities Service Chillo Cutting Oils. Contact your nearest Cities Service representative or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N.Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

Analyze both Sulfur and Carbon content in ONE operation





LINDBERG
Combined Sulfur-Carbon Determinator

Model DS-C—Takes minutes instead of hours. Reduces equipment cost.

Actually, this unit does the same work, in less time, than the two separate units you may now be using. It does combustion sulfur analysis (A.S.T.M. E30–47) and also has a gravimetric absorption system for carbon analysis.

Sulfur contents up to .30% can be analyzed with a one gram sample. Sulfur analysis can be made alone, in 3 minutes or less, by disconnecting the absorption system.

It's easy to clean this unit, because the sealed titration vessel has fill and drain tubing connections. This also reduces the chance of breakage, since the vessel does not have to be removed for cleaning.

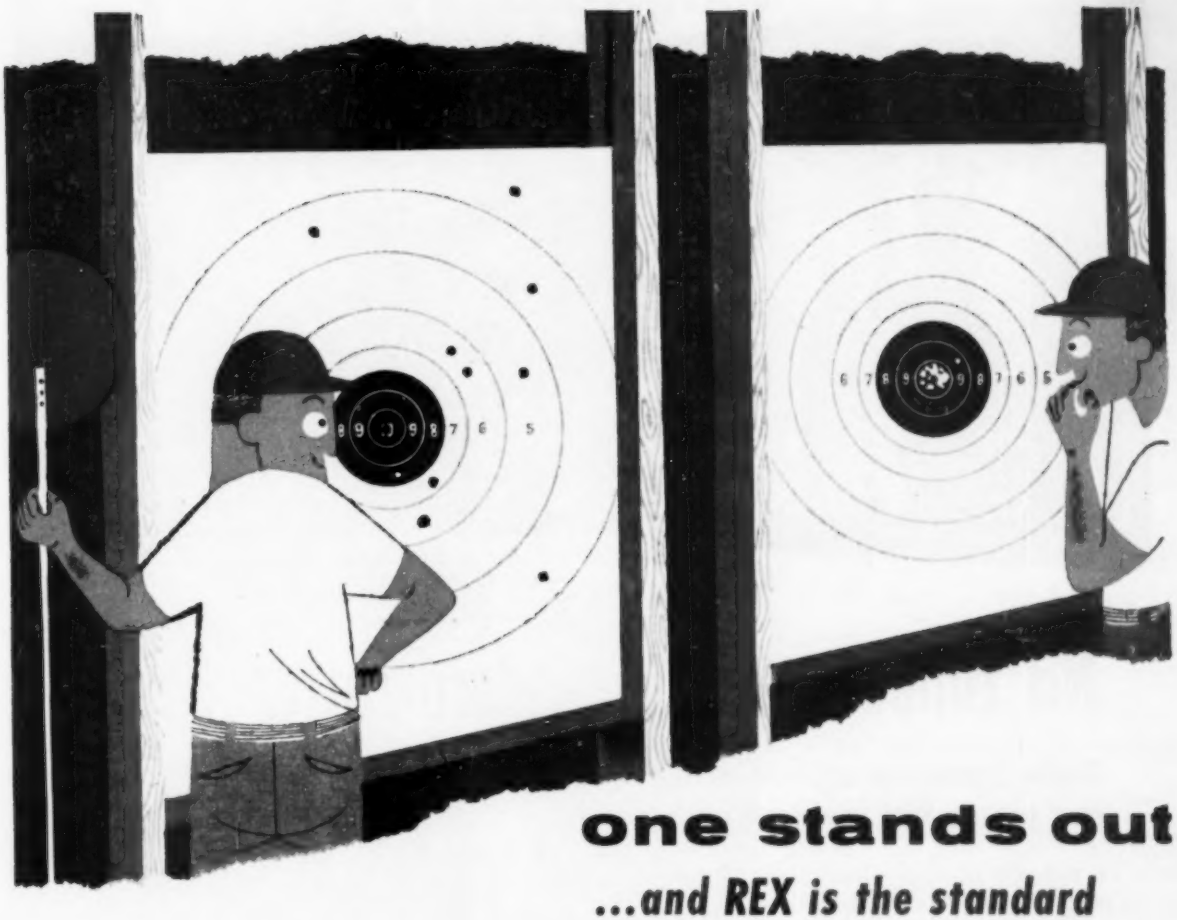
Errors are eliminated because you do not have to remember the initial color or shade before titration. It has a mirror surface that permits color end point comparison.

The Lindberg Combined Sulfur-Carbon Determinator cuts equipment costs way down—and at the same time saves plenty of work hours. This makes it just about perfect for the small lab, or for the lab that must analyze both carbon and sulfur on every sample.

If you want to know more about this unit, just call your nearest Lindberg laboratory equipment dealer. He will be happy to give you full details.

LINDBERG LABORATORY EQUIPMENT DIVISION

Lindberg Engineering Company, 2448 West Hubbard Street, Chicago 12, Illinois



one stands out

...and REX is the standard by which all high speed steels are compared

It takes exceptional skill *and* experience to make consistent scores on the target range . . . or to produce consistently superior high speed steels.

Crucible has been making REX® High Speed Steels for over half a century . . . and REX is still the standard of comparison wherever high speed steels are used. That's no idle claim . . . and you can prove REX's superiority for yourself by putting a piece to work in your own shop. You'll like its hardenability, response to heat treatment, and good tool performance.

Once you've tried it, we think you'll agree — *you can't find a high speed steel that will outperform REX.*

CRUCIBLE first name in special purpose steels

54 years of Fine steelmaking **TOOL STEELS**

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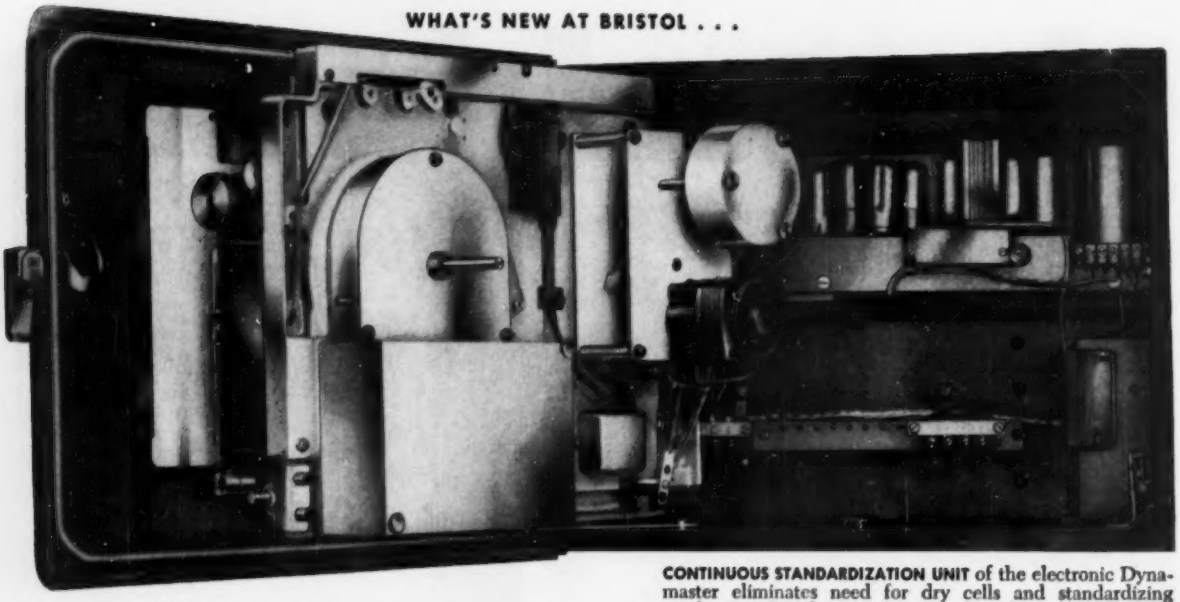
Canadian Distributor — Railway & Power Engineering Corp., Ltd.

WHAT'S NEW AT BRISTOL . . .



CONTINUOUS STANDARDIZATION UNIT of the electronic Dynamaster eliminates need for dry cells and standardizing mechanism. Result: no interruptions in the operation of the potentiometer for standardization; no batteries to replace.

No time out for standardization here

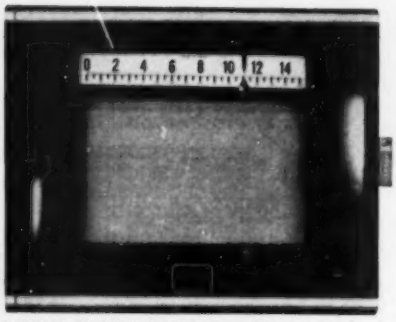
Bristol Dynamaster potentiometer pyrometers give you No-Batt continuous standardization

• You don't have to put up with interrupted performance from old-fashioned potentiometer pyrometers any longer!

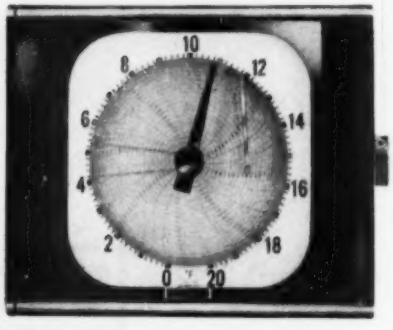
When you use a Bristol thermocouple or radiation-type Dynamaster, you get a *continuous* record or control of temperatures up to 4000°F in any type of fuel-fired or electric furnace or heating equipment. Thanks to the exclusive No-Batt continuous standardization which eliminates the need for dry cells in these electronic instruments, Bristol has been able to do away with interruptions formerly required for periodic standardization.

Bristol electronic Dynamasters are made in round- and strip-chart, single- and multiple-record recorders, air-operated and electric controllers with all types of control actions. Two-pen and program control.

For the complete story on the modern human-engineered Bristol Dynamaster, write for free 35-page booklet P1245. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.



BRISTOL DYNAMASTER CONTROLLERS in either the strip-chart model (shown above) or round-chart model, may be electrically or air operated. 2 position, 3 position, proportional, manual with automatic reset, or proportional input controls. On - off, proportional or reset air controls.



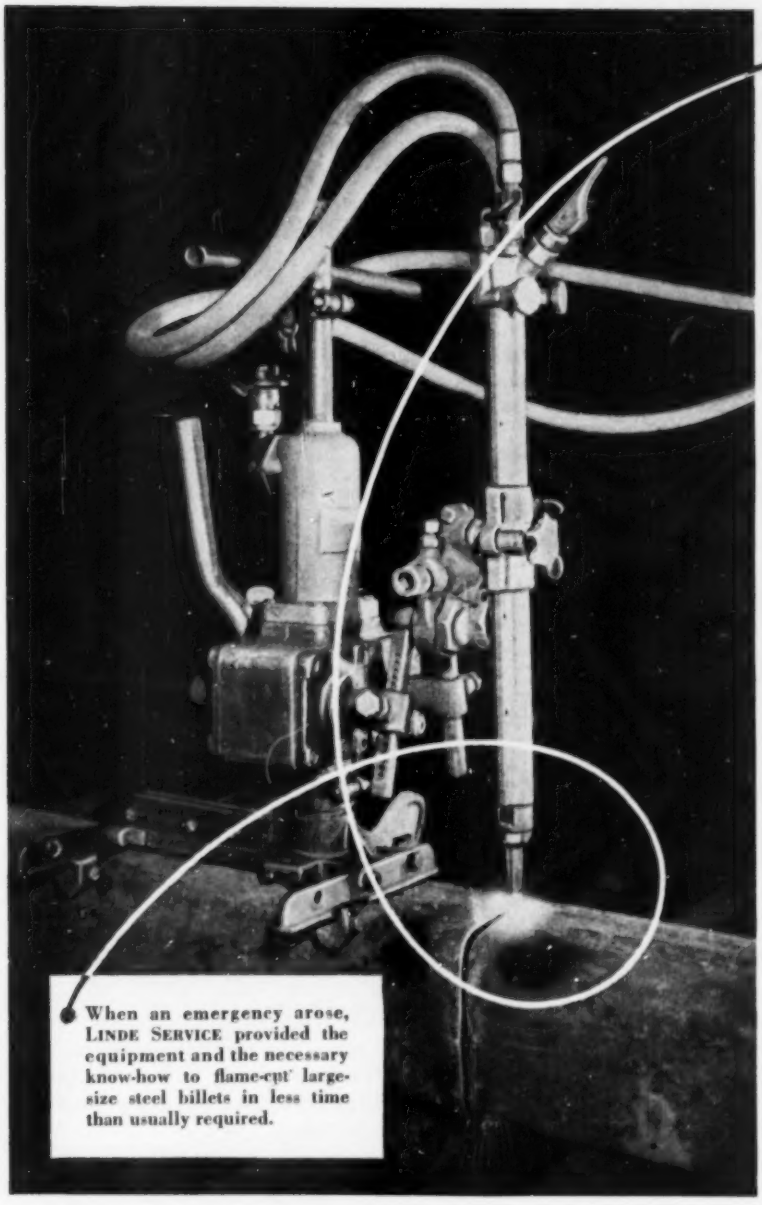
BRISTOL DYNAMASTER RECORDERS come in easy-to-read round-chart (shown here) or strip-chart models. Single record, multiple record or continuous 2 record designs are available. Bristol also supplies all types of time-temperature program controllers.

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

How LINDE SERVICE*...and Oxygen SOLVED THIS CUTTING PROBLEM



When an emergency arose, LINDE SERVICE provided the equipment and the necessary know-how to flame-cut large-size steel billets in less time than usually required.

When a hot saw broke in a Pennsylvania rolling mill, LINDE SERVICE was called in. LINDE engineers quickly set up four oxy-acetylene bar-cutting machines. Four hundred tons of 7⅝-inch alloy billets, each 40 feet long and each requiring four cuts, were handled at a temperature of 400 degrees. The whole job, including loading and unloading, took only seven hours. And half of the flame-cutting machines were manned by inexperienced operators!

The mill people were well pleased with the results—so much so, that they intend to use the same flame-cutting method every time a job like this comes up.

*LINDE SERVICE

is the unique combination of research, engineering, and more than 40 years of accumulated know-how that is helping LINDE customers save money and improve production in their uses of oxygen and oxy-acetylene processes.

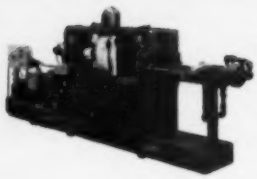
If your company uses oxygen, LINDE SERVICE can mean dollar savings to you. Let us tell you more about it.

LINDE AIR PRODUCTS COMPANY
A Division of UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street UCC New York 17, N. Y.
Offices in Principal Cities
In Canada: Dominion Oxygen Company
Division of UNION CARBIDE CANADA LIMITED

Linde

most aluminum die castings can be made on the low-cost

LESTER HP-1-C?



The group of aluminum die castings shown here ranges in overall size from a modest 7" x 4-3/4" to a respectable 11" x 8-5/8". The comparable range of weight is 9-1/2 ounces to 1 pound 12-3/4 ounces. A conservative estimate is that this range includes about 80% of all aluminum die castings being made today.

The average die caster would probably schedule these castings on a 400 ton machine. *Yet every single one of the castings shown was run on the Lester-Phoenix HP-1-C, rated at 200 tons of clamping!* Just think of the savings in machine-hour-costs that are effected by casting such parts on the comparatively inexpensive HP-1-C.

A vital part of the success of the HP-1-C is the one-piece alloy steel frame, perfectly and permanently aligned. This assures an *effective* clamping pressure of well over the rated tonnage.

Sid Wills, Shop Superintendent at Johnson Motors where most of these castings are being run on five HP-1-C's, says "We like the HP-1-C's. They're rugged, fast and easy to maintain." Write for complete specifications. IMMEDIATE DELIVERY.

LESTER-PHOENIX DIE CASTING MACHINES

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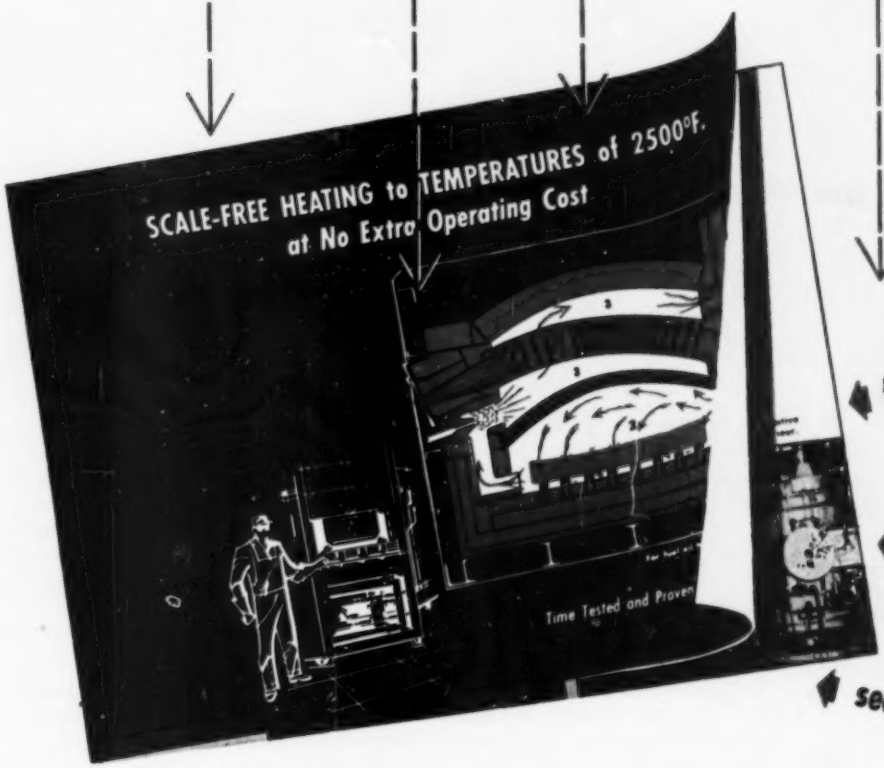
HOTTEST NEWS IN INDUSTRIAL HEATING

is in this Lithium Company Brochure



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secret of economies

● Everybody's talking about the new Lithium Company 2-Stage Hot Atmosphere Recuperative Furnace Systems, clearly pictured and described in 4-color process illustrations.
Get the facts about this advanced design for precision forging and rolling ferrous and non-ferrous metals . . . uniform, scale free, WALL-TO-WALL HEATING up to 2500°F.

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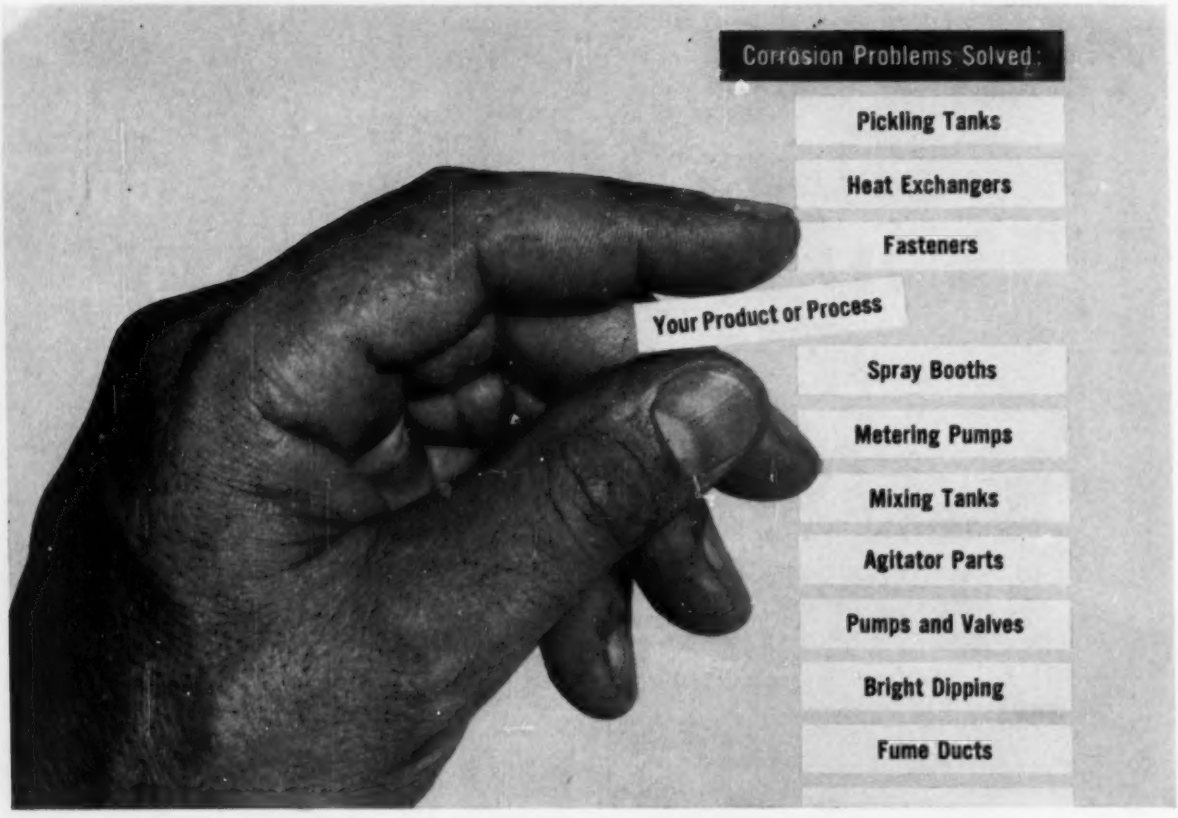
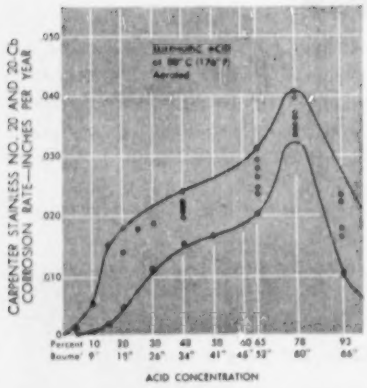


When will you add *yours* to the list?

How *sure* are you that your troublesome corrosion problems can't be licked? We've helped to solve a lot of "toughies", and we'd like to help you with yours. For example, one plant had a problem with Stainless Type 316 tie rods exposed to a solution of sulphuric acid ranging from 0% to 58%. Temperature: 158°F. (70°C.). After changing to Carpenter *Stainless No. 20*, life of the rods increased from 4 days to 256, and the *No. 20* rods still don't show any signs of corrosion. This is just one job report of many that shows what happens when plants change from ordinary stainless steels to Carpenter *Stainless No. 20*.

There is no other stainless on the market quite like *Stainless No. 20*. It was developed after seven years' research in Carpenter laboratories. It combines good workability with super resistance to many types of hard-to-handle acids (including sulphuric) at high operating temperatures. And in the short time it has been available, *No. 20* has added months, sometimes *years*, to the life of equipment such as mixing tanks, heat exchangers, process piping, pump and valve parts, bolts, nuts, tie rods, pickling racks, etc.

Here is your opportunity to realize *new* freedom from corrosion headaches. Tell your Carpenter representative you want to see the new No. 20 Comparative Corrosion Kit containing proof of super corrosion resistance. Or, to get started in testing No. 20 now, drop us a line for test coupons. THE CARPENTER STEEL CO., 133 W. Bern St., Reading, Pa.



Carpenter Stainless No. 20-Cb is available from The Carpenter Steel Company, Alloy Tube Division, Union, New Jersey, in the forms of tubing, sheet, strip, pipe and plate; and Stainless No. 20 in the forms of bars, billets and wire. In addition, many other No. 20 fabricated parts are available from various manufacturers. Write us for their names.

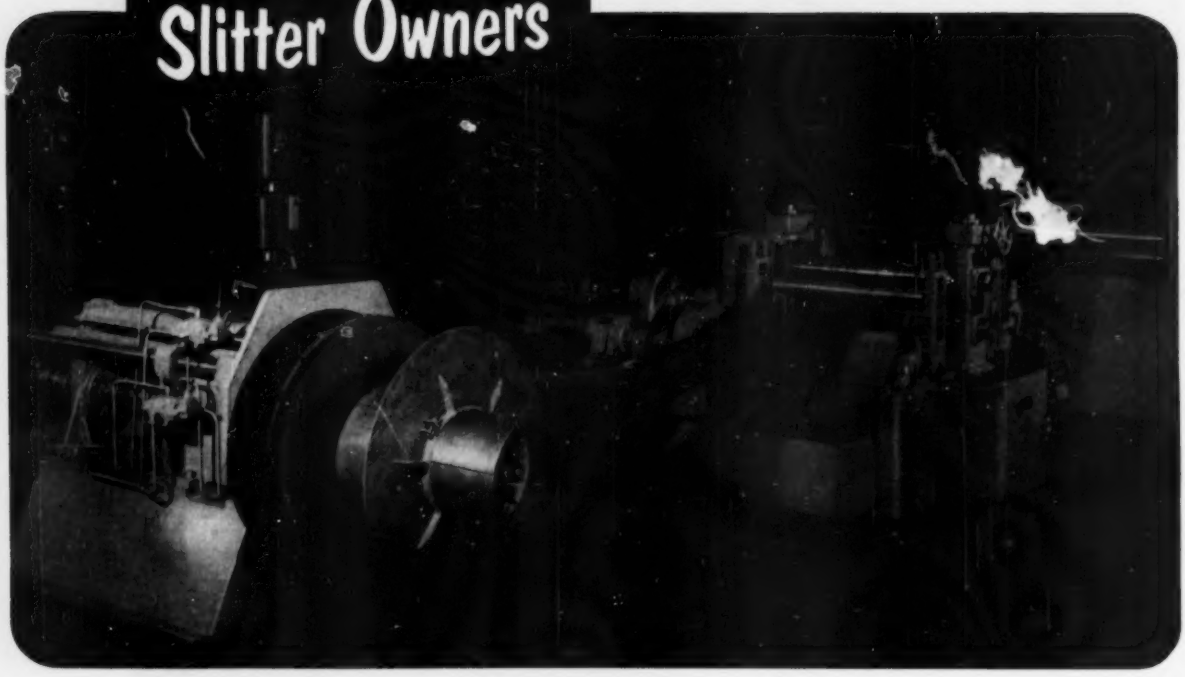
Carpenter STEEL — Stainless No. 20

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research
Export Department: The Carpenter Steel Co., Port Washington, N.Y.—"CARSTEELCO"

Picker *specializes* in x-ray, and x-ray only, covering the field like a blanket. *Whatever you need, we've got* . . . from a simple lead letter to a 22,000,000 volt betatron. To serve you, there are sales offices and service depots in all principal cities, staffed by skilled engineers prepared to cope with any x-ray problem promptly and with understanding. If you are now using x-ray, or are wondering whether you should, you can depend on Picker for objective technical counsel and efficient handling.

PICKER X-RAY CORPORATION 25 S. Broadway, White Plains, N.Y.
SALES OFFICES AND SERVICE DEPOTS IN PRINCIPAL CITIES OF U.S.A. AND CANADA

Ask any number of Yoder Slitter Owners



how they like it, and you may get as many different answers, because the benefits are so many.

One manufacturer said: "Our strip inventories have been reduced by 60% and greatly simplified. Our requirements in slit strands can now be quickly met from a relatively small stock of mill-width coils." Another manufacturer remarked: "We no longer have to worry about ordering strip long in advance, complicating our production planning." A third manufacturer made this comment: "We can now buy our strip wherever we can get the best quality, price and delivery. That saves a lot of time, money and worry."

Any one of these and other benefits may in itself be sufficient to justify the investment; yet, quite aside from this, the *direct savings in slitting cost always repays the investment in a short time,* often in less than a year.

Ask for the Yoder Slitter Book. It contains cost studies, time studies, information on scrap disposal, coil handling, small versus large slitters, and many other subjects of interest to users of coiled strip and sheets.

THE YODER COMPANY
5595 Walworth Ave. • Cleveland 2, Ohio

Complete Production Lines

- ★ **COLD-ROLL-FORMING** and auxiliary machinery
- ★ **GANG SLITTING LINES** for Coils and Sheets
- ★ **PIPE** and **TUBE MILLS**—cold forming and welding

ENGINEERING YODER MANUFACTURING

68 leak-proof joints in 2 2/3 minutes

SIL-FOS brazing does it!

This job goes to prove once more that you can't beat the brazing of non-ferrous metals with the low-temperature silver alloy SIL-FOS. And it also shows what a simple matter it is to get fast, economical production with SIL-FOS. Brazing return bends on the condenser and the evaporator of the FEDDERS room airconditioner is the job — and here's how it's done.

Photos and data courtesy of Fedders-Quigan Corp., Buffalo, N. Y.

A SIL-FOS wire rings are placed on ends of return bends and positioned in the simple jig in lower left.

B Return bends with SIL-FOS rings in place are assembled on the tubes of the condenser.

C The 3 rows of return bends are brazed at one time in this simple gas-air burner set-up — 40 joints in less than 1 minute.

Return bends on the evaporator are done the same way — 28 joints in 1⅔ minutes.

BULLETIN 20 tells how to get fast brazing production

It gives complete facts about low-temperature SIL-FOS brazing and goes into detail about good joint design and fast production brazing methods. Write for a copy today.

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FOUNDATION
makes the difference

put your finish on a sound phosphate base . . .

NORTHWEST INTERLOX

Interlox was developed by Northwest's Cleaning Specialists to give you a better, more corrosion resistant, more easily controlled phosphate base for your organic finishes. It exceeds most government specifications.

Deposited as a fine, dense grain coating, Interlox is designed for spray or immersion type baths—zinc phosphate coatings or iron phosphate coatings.

Interlox deposits at a very rapid rate thus assuring a high-quality, uniform coating throughout the unusually long life of the bath.

Northwest's production-tested chemicals and "Right the First Time" recommendations will save you money. For the complete story on Interlox or any of the other Northwest Chemicals write or phone for a Cleaning Specialist.

Got a problem? Let our cleaning experts help you!

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation, Export Distributors: Bethlehem Steel Export Corporation

Cam Follower, Made of Lehigh H, Speeds Production of Axle Shafts

You're looking at an axle shaft, being turned in the plant of Brunswick Ordnance Corporation, New Brunswick, N. J. The operation is performed automatically at high speed through the ingenious use of the cam follower shown in the foreground. This flat piece of steel, ½ in. x 2 in. x 40 in., is machined on one side to the contour of the finished shaft. It moves parallel to the rough bar, making contact with a wheel, beneath the coolant pipe, which in turn actuates the carbide bit.

Engineers at the Brunswick plant needed a steel with good machinability for the cam follower. But above all, they wanted maximum resistance to wear. Which steel did they choose? Lehigh H, our special-purpose high-carbon, high-chromium tool steel.

Lehigh H, an air-hardening steel, is ideal wherever good machinability, maximum wear and minimum distortion are important. It's safe for intricate dies having sharp corners. What's more, it's a deep-hardening steel, with high compressive strength.

Your tool steel distributor has a good stock of Lehigh H. Or you can order a supply direct from our mill depot.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Tool Failures Can Be Caused by Magnetism

Magnetism of either stock or tools can cause mystifying failures of tools. This is particularly true of punch-and-die sets, blanking tools, and occasionally, forming tools. Difficulties traced to magnetism can develop in these ways:

1. Improper feeding or positioning of stock.
2. Improper ejection of parts or scrap.
3. Several multiples feeding in at one time on some operations.

Overloading of tools produced by any of these three conditions can cause tool failure. Besides, magnetized parts pick up steel "debris," which acts as an abrasive on cutting edges, resulting in rapid tool wear. Steel stock can be magnetized by lifting with magnets, or by passing near electrical machinery or power lines carrying heavy currents. Tools are often magnetized by being ground on equipment using magnetic chucks. They can also be magnetized by other accidental means.

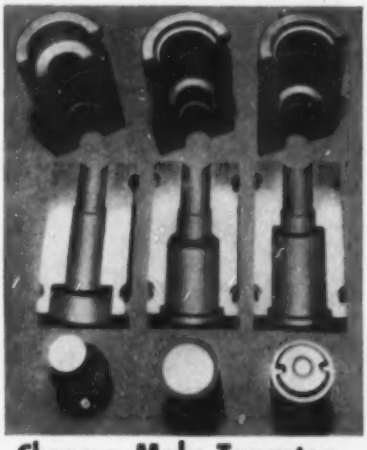
When steel parts or tools show evidence of magnetic attraction to each other, or when the edges attract steel chips or debris, steps should be taken to eliminate the magnetism. With steel stock, this can be done by tempering. But tools must be demagnetized with a demagnetizing coil, by passing them slowly in and out of the coil while it carries alternating current.

BTR HOLLOW-BAR SAVES PRODUCTION TIME

Using hardened bushings? Ring dies? Draw rings? Other ring-type applications? Then you'll find you can save time with BTR (Bethlehem Tool Room) Hollow-Bar.

BTR Hollow-Bar is made from our popular oil-hardening tool steel by a process called high-speed trepanning, in which hammer-forged round bars are cored out in the center, and are then rough turned on the outside. The operation is much like gun drilling, except that in trepanning, the cutter produces a solid bore from the bar center.

With BTR Hollow-Bar, there's no need to wait for forged rings or discs. Nor is there any drilling, rough boring, rough facing or rough turning required. You can get full particulars about BTR Hollow-Bar from your tool steel distributor.



Chrome-Moly-Tungsten Lengthens Die Life

Shown here are sets of forging insert dies and (at bottom), upset punches, used in a hot-work application. The heat-treatment consists of air-quenching and double-tempering to Rockwell C 35-41 for the inserts, and Rockwell C 45-49 for the punches. Said the user, "We like the minimum size change when heat-treating CMW. We get less heat-checking on die impressions, and better resistance to washing effect. And they add up to long die life, which is just what we want."

Position Open on ASM Staff

- *This director of metals engineering education for ASM should have superb qualifications as a metallurgist (preferably a Ph.D. degree) but he should be much more than a scientist—he should be one who cares deeply about the practical consequences and the day-by-day usefulness of applied metallurgy in industry.*

- *He should have a conviction that metallurgical engineering can be brought to occupy a much larger place in industrial affairs than it does today. He should feel that the soundest method for achieving this larger place and recognition is through a broad program of adult education, which he will administer. He should understand instinctively the needs of design engineers and process engineers for this type of supplementary training in metals, and should be able to sense the still broader opportunities inherent in the training of large numbers of subprofessional technicians, draftsmen and production supervisors along the same lines.*

- *He should be able to glimpse a future metalworking industry in which metallurgy is the recognized and respected basis for all operations and in which a very large number of engineering and supervisory production personnel will have a common understanding of the importance of metallurgy because of their participation in the ASM correspondence courses in metals engineering.*

- *The man selected for this position should, of course, have the ability to plan and evaluate instructional materials. No less important, he should be endowed with the personal qualities and the persuasiveness necessary to win friends for this program among the top managements of metalworking companies as well as his colleagues in the headquarters' staff.*

- *He should be capable of growing with his own program, for this activity, skillfully administered, may justifiably become the largest department of the ASM.*

- *The new appointee, a metallurgst of 35 or under, might be either a young man who now contemplates leaving a university post and who has had some prior industrial experience, or one who now heads a small group or department in industry and has had some previous teaching experience which he enjoyed. The responsibilities and starting salary will be commensurate with those of a full professor of metallurgy in a leading university.*

- *Please send a resume of your qualifications and experience to:*

W. H. Eisenman, Secretary

American Society for Metals
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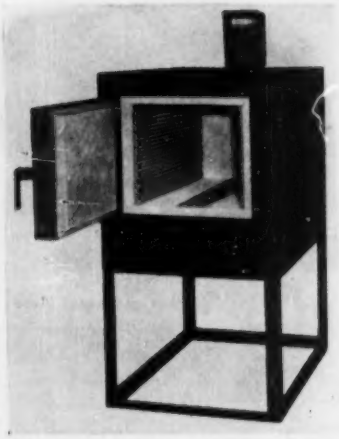

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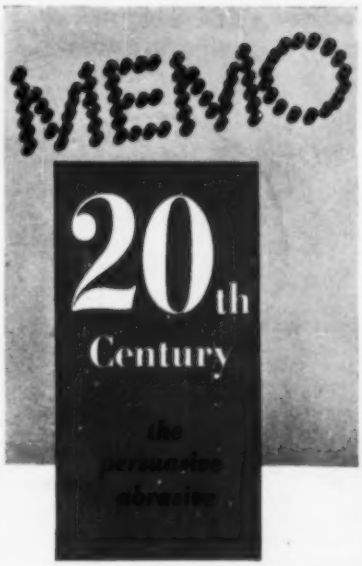

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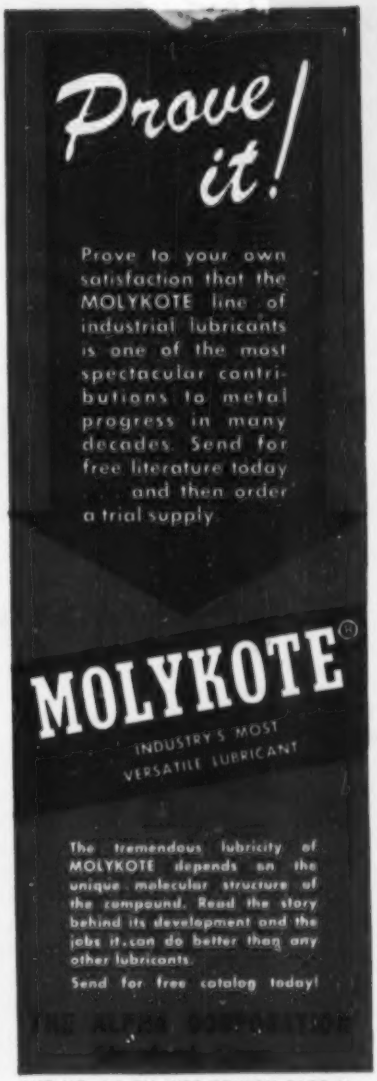

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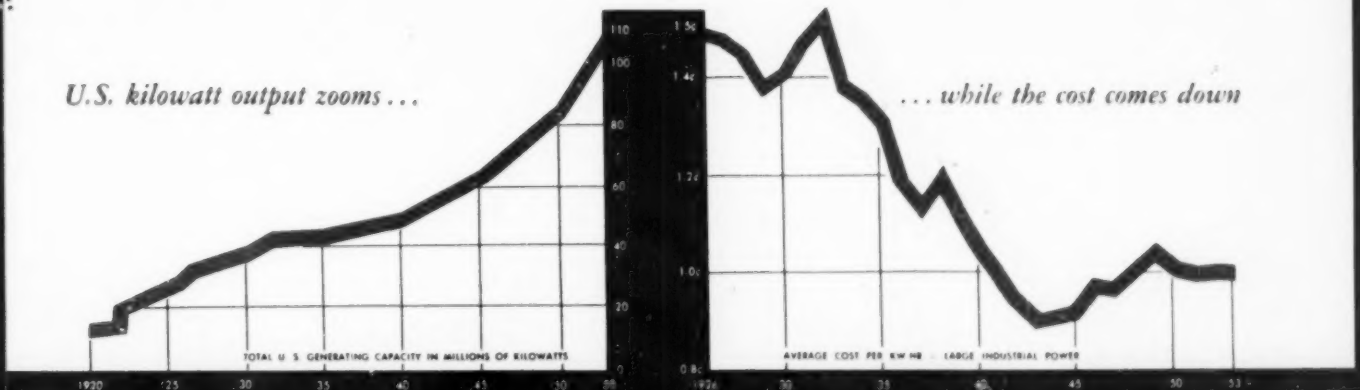
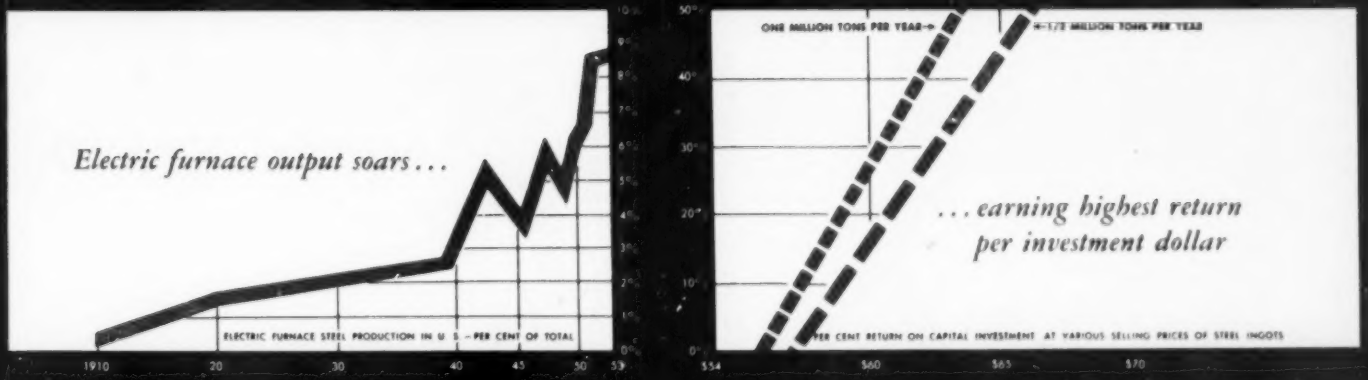
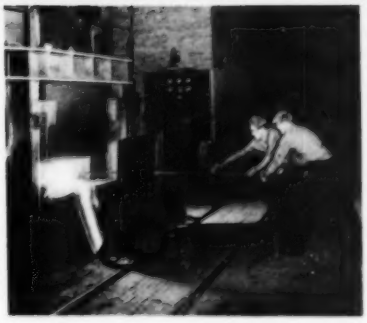


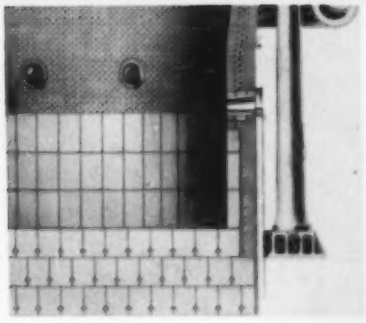


IN THIS ISSUE

Guest author Charles W. Vokac brings broad experience to his subject: THE ELECTRIC ARC FURNACE—AN APPRAISAL FOR MANAGEMENT.



Graphite slag-door sills cut costs, improve handling of high temperature slags in electric furnace production of stainless steels.



New design of carbon blast furnace linings features thicker, "locked-in" hearth-beams, accurately machined mating surfaces.

CARBON AND GRAPHITE NEWS
DECEMBER, 1954—Vol. 1, No. 2

THE MANY letters received praising the article by guest author W. B. Wallis in the first issue of CARBON AND GRAPHITE NEWS confirm our decision to make these pages, in part at least, a forum for industry's leading spokesmen.

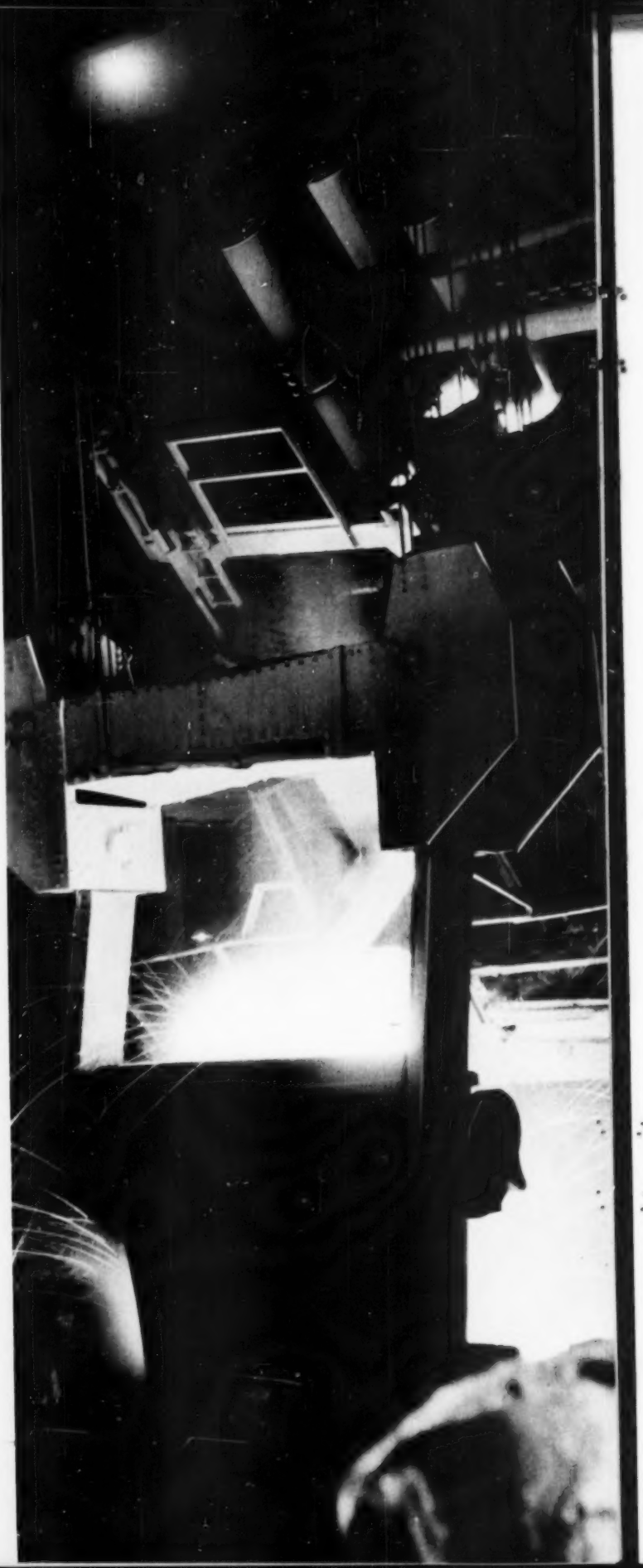
The interests and problems of Management, whether executive, administrative or operating, are very similar and, of necessity, parallel. With concern for economy and efficiency at an all-time high, C. W. Vokac's article in this issue, THE ELECTRIC ARC FURNACE—AN APPRAISAL FOR MANAGEMENT, would seem to be especially timely for the steel industry. Mr. Vokac has deliberately avoided a detailed discussion of any one phase of electric furnace operation in order to bring you a broad, general picture of its role in modern steel manufacture.

Future issues of CARBON AND GRAPHITE NEWS will deal in more specific terms with various aspects of the electric arc furnace, and spokesmen on these subjects will be among the most highly qualified men available within the industry.

You may be sure that no effort will be spared to sustain this publication at a high level of industrial service, and we hope you will continue to make your suggestions known to us at every opportunity.

A. F. Johnson

PRESIDENT



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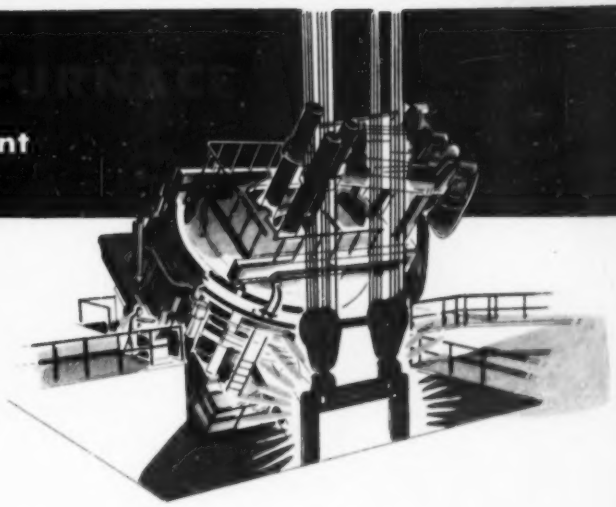
THE ELECTRIC ARC FURNACE

...an appraisal for Management



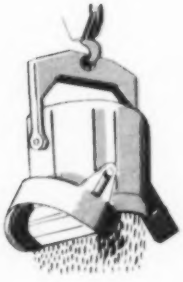
By Charles W. Vokac

With the Steel Industry's backlog a thing of the past and the search for new markets and more efficient methods intensified, operating management should be more than ever aware of the electric arc furnace as its most flexible and dynamic production tool.

It's the expanding nature of the electric furnace—its rapid growth in size, design and application—which requires constant re-appraisal by and for management, both operating and administrative.

It is not the purpose of this discussion to add to an already voluminous library of electric furnace technical data, but rather to evaluate its known characteristics and capabilities in the light of *current* management problems such as: a reduced work-week, fluctuating markets, high fuel and materials costs and increasingly competitive interest among steel producers in a product of high, uniform quality at lowest cost.

After the following brief review of major applications, an analysis is made of some specific ways in which modern arc furnaces meet steel management's toughest problems. Among the topics considered will be: "on-and-off" economy; the relation of temperature control to the critical consideration of product quality; heat efficiency vs. fuel cost; increased capacity and its relation to production expense; a summary of electric furnace features as they affect distribution of fixed charges, maintenance and pay-out of equipment, and overall plant efficiency. All these factors are parts of the delivered-price equation which determines who gets what portion of how much business.



Variety of Uses

In the iron foundry, the arc furnace is a familiar piece of equipment. It is quite widely used as a complement to the cupola to duplex cupola iron. By this practice, the increasing demand for closer metallurgical control of the iron and of its temperature is being met despite the continually decreasing quality of materials available for cupola charging. The addition of the electric furnace to this operation not only has improved the quality of the iron being cast but has reduced its cost as well. Where economic conditions are favorable, and the tonnage is low enough, arc furnaces alone do the entire job – melting, heating and refining at less cost per ton.

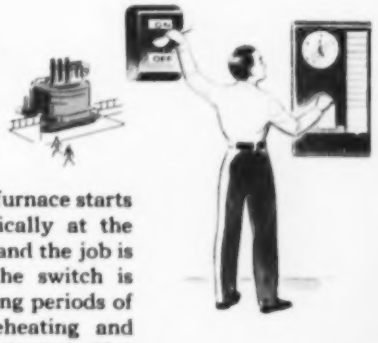
In the steel foundry, the electric furnace has been doing these jobs for over a generation. It produces all types of steel castings. Comparatively few steel castings are now made with other than electric furnace steel.

The arc furnace has been producing tool steels and other alloy steel ingots for a long time. Over the past several years it also has made a considerable proportion of the ordinary carbon steel ingot tonnage in steel plants and the proportion is becoming greater every year.

In calcium carbide and ferro-alloy plants the electric arc furnace is extensively used for production of carbides, ferrosilicon, ferrochrome, phosphorus, silicon and many other allied products. Today, electric arc furnaces do many other smelting and melting operations which cannot be done practically or efficiently with any other type of equipment.

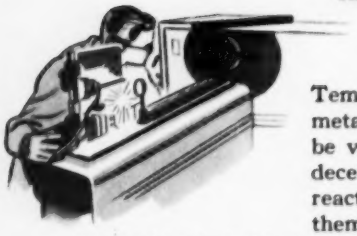
New applications of the electric arc furnace are being continually developed and expanded; its possibilities seem almost limitless. Processes which for generations have been carried on in gas, oil or coal-fired furnaces now are performed in electrics. Increasing demands for new metals, new alloys, new materials, and for improved qualities of the older ones are being met by the arc furnace.

On-and-Off Economy



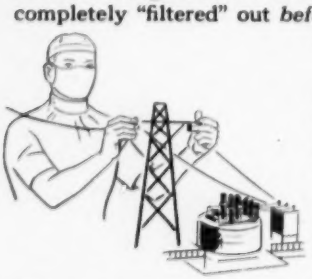
The electric arc furnace starts producing practically at the turn of a switch and the job is finished when the switch is turned again. Long periods of preparation, preheating and soaking are eliminated. Neither is there lengthy preparation for shut-down. Arc furnaces can be economically fitted to the more desirable, single-shift, 5-day-week schedule of operation.

Closer Metallurgical Control Improves Product



Temperature is a useful metallurgical tool and can be varied to accelerate or decelerate certain chemical reactions and even reverse them. In the refining process, it is highly desirable for one to be able to vary the temperature of the charge at will and to have complete control of it. In the electric arc furnace the temperature of the charge can be regulated to a high degree of accuracy.

Metallurgical control in all furnace processes is paramount. Control over what goes into the furnace is of equal importance in order to control the quality of the product from the furnace. Particular effort must be exercised to prevent any deleterious elements from entering the furnace. Gas, oil, coal and coal derivatives when fired in metallurgical furnaces, carry undesirable elements into them. These elements contaminate the charge and often uncontrollably change its character. Electric energy, on the other hand, is a perfect metallurgical fuel – *there is no other fuel like it.* The power companies are able to burn the lowest grades of coal, gas or oil (the better grades are rapidly becoming exhausted) to generate this "perfect fuel". All the contaminating elements and gases thus have been completely "filtered" out *before* this fuel reaches the electric furnace.



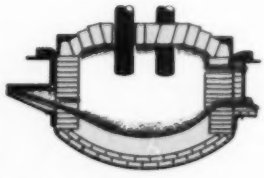
The materials available for charging the furnace seldom are of the same chemical analysis as that required in the product. In the electric arc furnace, the charge, after it is melted, may be worked under an oxidizing, a reducing, or a neutral slag. This *chemical* control, and the *temperature* control already mentioned, permit a wide selection of lower-cost charging materials and result in extremely efficient metallurgical control of the product.

By such close control, desirable alloys in the charge may be retained with a high degree of recovery; alloys required in the product and not present in the charge can be added, also with a high degree of recovery; and alloys in the charge but undesirable in the finished product can be reduced to practically any desired limit.

Operating Costs Down

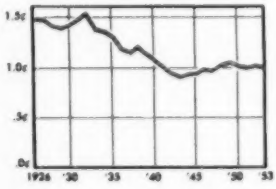
- Operating costs are reduced because the furnace can be turned on or off conveniently with no delays. The furnace is producing as soon as it is turned on and keeps producing until it is turned off.
- Operating costs are reduced because the furnace can be operated during regular working hours of the day and regular working days of the week. The efficiency of the personnel is also improved.
- Operating costs are reduced and the quality of the product is improved because the operator has complete control over the temperature of the burden within the furnace.
- The cost of the product is reduced because lower-cost materials can be used in the charge.

High Heat Efficiency



Since electricity is of a high order it can be completely converted into heat. Since the arc can be almost completely enveloped by the charge, the thermal efficiency of the electric arc furnace is the highest of all furnaces by a large margin.

Low-Cost "Fuel"



The cost of electrical energy is becoming more and more favorable as compared with other fuels. The unprecedented growth of the power generating industry and more stable and higher capacity power distribution networks make it possible now to feed the arc furnace with all the energy it can take and as fast as it can take it. The result is a furnace which is faster, more productive and more economical, further improving its competitive position and its broadening use for more and new processes.

Improved Designs Increase Capacity, Reduce Costs

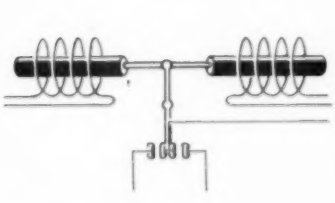
Improvements in the design of the electric arc furnace are keeping pace with other developments and demands

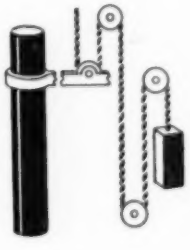
Product Quality Up

- Cost of the product is reduced because lower cost alloys can be used, less alloying is needed and a high ratio of alloy recovery is attained.
- Quality of the product is improved because the operator has complete control over everything that goes into the furnace including the "fuel" which has been "filtered" in the power-generating plant.
- Costs go down and production goes up because the availability of useful equipment is increased. Side-charged furnaces require approximately an hour for the charging operation; the top-charged furnace can be charged in a few minutes. Slipping electrodes in old screw-and-wedge type clamps required several minutes; with automatic electrode clamps, it can be done in seconds, and by one man instead of two.

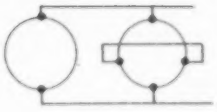
of the industry. The electric arc furnace has been made steadily more productive by the addition of the top-charging feature, the automatic electrode clamp, improved electrodes and refractories, and general simplification and dependability of all components comprising the complete installation.

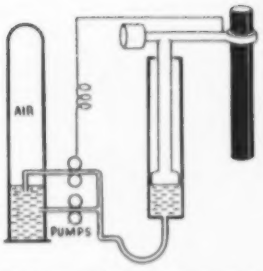
Greater and more efficient utilization of the power delivered to the furnace is made possible by the improved furnace controls used today. Automation began with a contact-making ammeter to operate the reversing contactors controlling the reversing electrode motor which, through a dead-ended cable drive, positioned the electrode and controlled the arc current. Later, a balanced-beam type of relay operated the reversing contactors and a balanced-cable drive positioned the electrode to control the arc current and voltage. Still



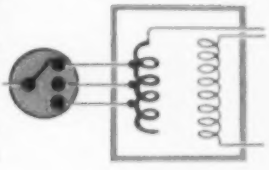


later, a differential field rotary generator operated the reversing electrode motor and an air-counterbalanced hydraulic electrode drive was used to control the arc voltage and current by responding to the degree to which the arc was off-balance. And now, a new control is available which essentially is a hydraulic differential energized directly from the furnace bus to control the product of the arc voltage and current that produces the heat generated within the furnace.



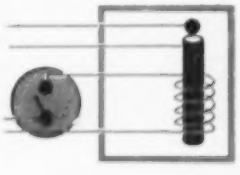


Automation also was applied to other components of the electric arc furnace, increasing its adaptability to additional processes. Tap changers on the furnace transformer were motorized so that the operator could make voltage-tap selections as the operation required, simply by turning a tap changer switch on his panel board.



Consideration is being given to general use of so-called "on-load" tap changers so that the operator need not turn off the power to the furnace to make voltage-tap selections. This would increase further the productivity of the furnace. However, the economics of this change have yet to be proved; the "on-load" tap changer costs more to build; at present it apparently cannot be built to prevent at least some arcing during its use and this is conducive to increased maintenance. On the other hand, its use would reduce maintenance on the furnace switch or breaker which would not be operated as frequently with the "on-load" tap changer. It appears that the initial increase in cost may be the sole criterion in this case.

Higher voltage melt-down taps are now being used for faster melting. Higher voltage means more heat input with the same current and avoids the need for overloading electrodes and circuits to obtain optimum production from the furnace.



The furnace switch or circuit breaker went through an evolution of improvement also. It, too, is now automatically operated with a switch on the operator's panel, increasing still further the availability of the electric arc furnace.

Concurrently with evolution of furnace design, suppliers of such vital accessories as electrodes and nipples have constantly improved the quality and design of their products. Today, graphite has virtually replaced carbon in such manufacture and brings to the modern electric furnace its advantages of higher conductivity, resistance to oxidation and high mechanical strength. Development of the tapered nipple joint and the smaller nipple sizes has cut column make-up time, reduced cost and improved efficiency.

(Concluded on last page)

Ferro-Manganese Cooling Beds

As an alloying agent in steel, ferro-manganese is a refining element because of its powerful attraction for oxygen and sulphur. It acts as a deoxidizer and cleanser of molten steel; it combines with the sulphur, thereby greatly improving the hot-working properties of the steel; and it acts as an alloying element to improve the strength, toughness and response to heat treatment of a wide variety of structural and engineering steels.

There is no doubt that the production of ferro-manganese has been plagued since its introduction into the steel age by the problems introduced by contamination and thermal difficulties that are common throughout the entire metals industry.

In the production of ferro-manganese, the hot metal, after melting and refining in the furnace, is poured into cooling beds or chill trays. Cooling beds have been of short life, are expensive to maintain, and contaminate the metal.

Many schemes have been tried to improve bed construction but none has met the requirements as well as carbon or graphite blocks to replace the cast iron slabs and bed dividers. One large manganese producer was having so much trouble with bed maintenance, short life, metal inclusions and other assorted difficulties that a decision was made in 1952 to try carbon lined beds.

At one of the company's mills there are eight beds placed in line, with a common feed header running the entire length, having suitable "gates" at each bed. The bottom of each bed now is lined with between 3,000 and 3,500 lb. of carbon. After placing the blocks in position the joints are filled and the surface coated with a clay and water slurry and recoated after each use. Carbon blocks also are used as bed separators, since the bed, essentially, is a single large one, divided into the eight separate compartments.

Between 35 and 40 tons of metal are cast into each bed at each tapping and a total of better than 8,000 tons can be cast before it is necessary to remove the blocks and make a new installation. This represents upwards of fourteen months of bed life in contrast to between nine and twelve months of service life from cast iron beds.

The result of carbon bed usage has been similar at both plants of the company. One notable difference, however, has occurred at one plant where two beds have been in service for over a year and show such a slow rate of wear they are expected to remain in operation for another year. Carbon lined beds have been so satisfactory that carbon or graphite will replace other materials as each bed is rebuilt.

The principal advantages of carbon lined beds that are emphasized by company officials are: lower cost (approximately one half as much per ton of metal as with former beds); the metal does not stick to the bed and, therefore, less time is required for its removal; the metal chills more quickly, due to the very high heat transfer rate of the bed material, thus improving the metal grain structure; and the metal is much cleaner.

The variety of sizes and shapes available in either carbon or graphite lend themselves to the design of large beds or small trays to handle both blast furnace and electric arc furnace production of ferro-manganese.

Graphite Slag-Door Sills

for electric furnace production of stainless steel

The making of stainless steel is a specialized phase of steel manufacture. The word "stainless" is synonomous with refinement, quality and silvery luster. Purity and quality must be there whether we visualize cooking pots, kitchen sinks, jet engine parts, steaming chemical cauldrons, structural shapes or beautiful ornamentation. It must be twisted, turned, welded, riveted, rolled, shaped and deep drawn, and it must be corrosion, rust and stain resistant, tough and strong. It is truly the aristocrat of steels.

The alloying elements in stainless steel require high furnace heats, while the cleansing agents are just as demanding. When dealing with a furnace charge that may be worth a small fortune, the ingredients must be blended carefully and closely controlled. The superheated, erosive, chemically reactive slag that collects the impurities from the seething metal is especially rough to handle. *Photo right*→

Copies of CARBON AND GRAPHITE NEWS, Vol. 1, No. 1, Featuring the article, "Electric Furnace Steel – Past, Present and Future", by W. B. Wallis, are still available.

Write National Carbon Company, 30 East 42nd Street, New York 17, New York, giving name, title and company address.

CARBON AND GRAPHITE WILL NOT STICK, SHRINK, MELT . . . . . .

The unique chemical and physical properties of carbon and graphite make them the most acceptable of all materials for metallurgical applications wherever "the metal runs hot". They are not wetted by molten metal or slag; they are dimensionally stable; they resist thermal shock; while their thermal conductivity is much higher than ceramic materials.

Future issues of CARBON AND GRAPHITE NEWS will show these properties in a variety of specific applications.

The problems of erosion, rapid wear, chemical action and sticking at the slag door have been solved at several mills by mounting a graphite sill at the door. One mill uses a piece of graphite approximately 16¼" wide x 20" long x 3⅛" thick. In addition, the slag run-out trough is lined with graphite.

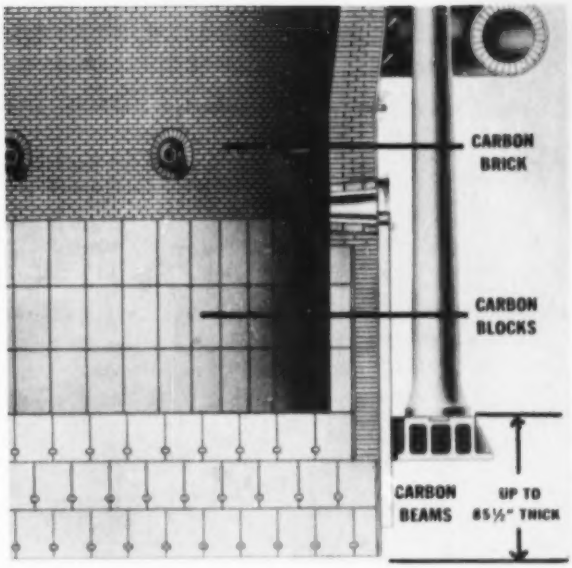
The slag does not stick to the graphite, the oxidation rate is very low and is further arrested by washing the surfaces with a clay and water slurry as soon as the slag ceases to flow. Each sill averages about twenty pours before it must be repaired.

Experience proves that the use of graphite in door sills and runners substantially increases their life, reduces the disagreeable and costly maintenance at these locations, saves time through much less frequent replacement and eliminates the extensive patching after each pour that formerly was necessary.

Blast Furnace Hearths

The early designs and installations of carbon blast furnace linings produced many very successful campaigns.

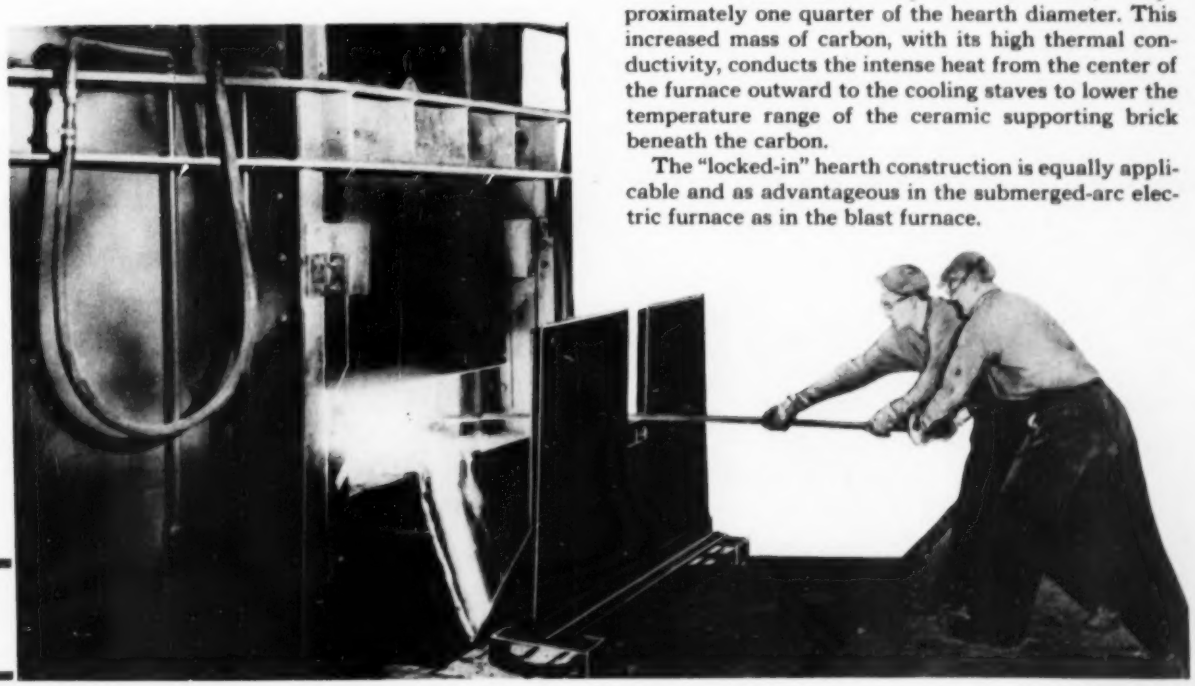
The experience and knowledge obtained from careful inspection and analysis of each furnace at the end of a campaign has been the basis for changes in the design of carbon blast furnace linings engineered by National Carbon Company to permit even more satisfactory service than before.



The horizontal hearth, in particular, retains the use of large beam sections but now adds the feature of longitudinal keys of round cross-section set into half-round keyways carefully machined in opposing faces of the vertical joints. The precision machined mating faces of each beam are coated with carbonaceous cement and the assembled hearth tightly clamped to produce an essentially monolithic carbon mass when it sets up. This provides the most practical "locked-in" construction, tieing in the blocks one to another. The 4-in. diameter rods, being joined continuously across the furnace to the cooling staves where the hearth side walls bear on this inter-locked mass of carbon beams, very positively produce an increase in mechanical strength for the entire bottom.

With this improvement in the details of construction, it is now considered more practical to increase the carbon bottom thickness up to 85½ inches, or approximately one quarter of the hearth diameter. This increased mass of carbon, with its high thermal conductivity, conducts the intense heat from the center of the furnace outward to the cooling staves to lower the temperature range of the ceramic supporting brick beneath the carbon.

The "locked-in" hearth construction is equally applicable and as advantageous in the submerged-arc electric furnace as in the blast furnace.



THE ELECTRIC ARC FURNACE

(Conclusion)

More Production Per Dollar of Investment

Increased availability results in a greater distribution of fixed charges, such as the power demand charge, investment, supervision, auxiliary services, etc. The new furnace controls, which maintain the arc a greater percentage of time and at more normal loads, have increased the load factor, reduced the surge factor and increased the power factor to further increase efficiency of operation. The new controls operate the electrodes faster and more smoothly to reduce the transfer of excessive mechanical loads upon them and prevent straining and breaking. They keep the electrodes out of the bath where they would be eroded quickly and would contaminate the charge. Mechanization has made operations easier, more consistently accurate and faster.

What is Ahead

If mechanization is carried further, as some are beginning to dream, the whole furnace operation will be programmed, recorded and automatically repeated. Can it be done? Will it be done? More fantastic things than this have been done before!

It was believed that the automatic electrode clamp could not be made practical. Now, everyone wants it on his furnace!

It was believed that electrodes could not be raised and lowered without reversing the electrode motors and that a furnace could not be controlled automatically without the usual furnace regulator. These things are being done now!

Continued exploitation of the inherent advantages of the electric arc furnace and continued development and improvement of its design will further promote the phenomenal expansion of its applications.

Credits

Charts, front cover, based on data contained in *Comparative Economics of Open-Hearth and Electric Furnaces for Production of Low-Carbon Steel*, a technical and economic study sponsored at Battelle Memorial Institute by Bituminous Coal Research, Inc., and fourteen electric utility companies; and reports of Edison Electric Institute.

Photo, inside front cover, courtesy: United States Steel Corporation.

Photo, inside back cover, courtesy: American Bridge Division, U. S. Steel Corporation.

CHARLES W. VOKAC *received his degree in engineering from the University of Illinois and has done post-graduate work in electrical engineering, metallurgy and management techniques.*

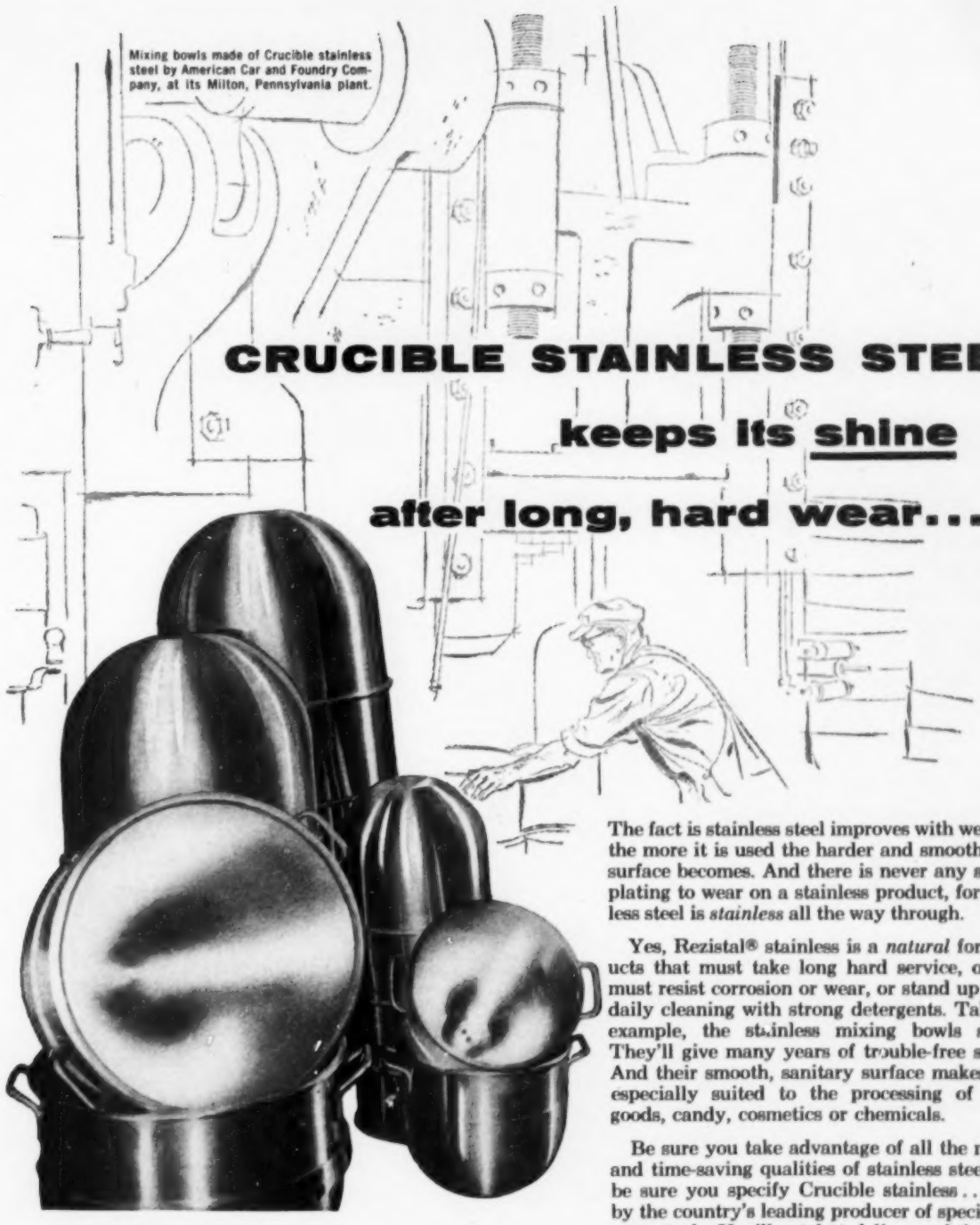
As manager, Hydro-Arc Furnace Department of the Whiting Corporation, he has travelled extensively in almost every industrial area in this country, as well as to locations in Canada, Mexico and South America. Mr. Vokac is the author of many papers on the electric arc furnace and holds patents on furnace controls and equipment.

A member of AFS, AIMME, ASME and the Society of American Military Engineers, Mr. Vokac also is active in the field of education. He is now completing his second year as President, Board of Education, Cicero, Illinois.

Clarksburg, West Virginia Works of National Carbon Company, A Division of Union Carbide and Carbon Corporation

This is the second of a series featuring the five plants of the company that are devoted to the manufacture of carbon and graphite electrodes.

The history of National Carbon Company is a chronology of "Firsts" – first with commercial production of both carbon and graphite electrodes in the early 1900's – first to introduce each succeeding larger size – first with tapered nipples and with smaller nipple sizes–first to produce carbon electrodes up to 45-inches diameter and graphite electrodes up to 35-inches diameter. Even larger electrodes and other massive shapes can be made with present facilities.



Mixing bowls made of Crucible stainless steel by American Car and Foundry Company, at its Milton, Pennsylvania plant.

CRUCIBLE STAINLESS STEEL keeps its shine after long, hard wear...

The fact is stainless steel improves with wear, for the more it is used the harder and smoother the surface becomes. And there is never any surface plating to wear on a stainless product, for stainless steel is *stainless* all the way through.

Yes, Rezistal® stainless is a *natural* for products that must take long hard service, or that must resist corrosion or wear, or stand up under daily cleaning with strong detergents. Take, for example, the stainless mixing bowls shown. They'll give many years of trouble-free service. And their smooth, sanitary surface makes them especially suited to the processing of baked goods, candy, cosmetics or chemicals.

Be sure you take advantage of all the money- and time-saving qualities of stainless steel. And be sure you specify Crucible stainless . . . made by the country's leading producer of special purpose steels. You'll get fast delivery of the grade and size you need when you call Crucible.

CRUCIBLE first name in special purpose steels

54 years of Fine steelmaking **STAINLESS STEELS**

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • MAX-EL • ALLOY • SPECIAL PURPOSE STEELS

EVERY NUMBER LEGIBLE because of die cast print wheels ...SO

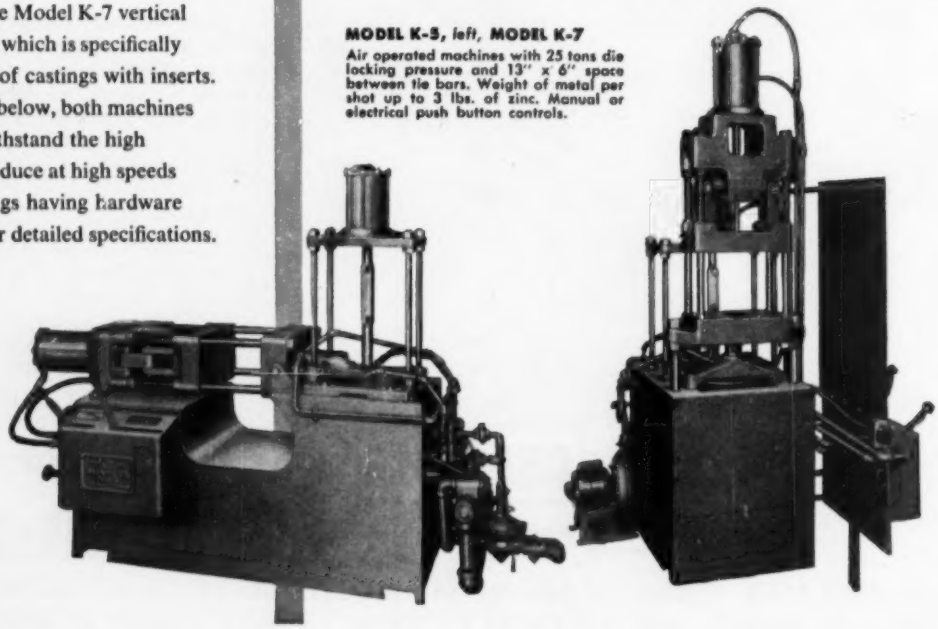
The mechanical brain of a Burroughs Corporation business machine cannot afford mistakes . . . every number must print in perfect alignment and be clearly legible. Helping Burroughs provide this unerring accuracy are radially cored die cast print wheels containing the numbers. These small print wheels, requiring machine tool precision and close tolerances, are made on KUX die casting machines. KUX machines were chosen because they can be depended on for casting parts of exacting dimensions with fine detail. Burroughs says production of print wheels has increased, "AND A BETTER PRODUCT IS OFFERED MORE ECONOMICALLY."

The wheels are cast on the Model K-7 vertical type center shot machine which is specifically designed for production of castings with inserts. Like the Model K-5, left below, both machines are massively built to withstand the high pressures required to produce at high speeds small, solid, dense castings having hardware quality finishes. Write for detailed specifications.

Burroughs chose Kux die casting machines

for production of these finely detailed parts

MODEL K-5, *left*, MODEL K-7
Air operated machines with 25 tons die locking pressure and 13" x 6" space between tie bars. Weight of metal per shot up to 3 lbs. of zinc. Manual or electrical push button controls.



KUX MACHINE COMPANY
6725 Ridge Avenue
Chicago 26, Ill.

UDDEHOLM STOCKS THE TOOLMAKER'S STANDBY

SAE/JIC-01 (Carbon .90%, Manganese 1.20%, Silicon .25%, Chromium .50%, Tungsten .50%, Vanadium .20%) is a time-tested, oil-hardening, non-deforming analysis for general tool and die work. Uddeholm calls it UHB-46. It is available from stock in all the forms illustrated:

1. UHB-46 drill rods
2. UHB-46 flat ground stock
3. UHB-46 hot-rolled bars
4. UHB-46 special sections
5. UHB-46 hollow bars

And, we will deliver UHB-46 in special forgings.

With such a wide variety of sizes, shapes, and finishes, you can make all heat-treated components of a tool or die from one analysis and get them all from one source—Uddeholm. From that same source you get Uddeholm Swedish quality and Uddeholm service.

Furthermore, you can get many other grades of tool and die steels. The most generally used types, in an extremely wide range of sizes and shapes, are always on hand. Stocks are carried in New York, Cleveland, and Los Angeles.

WANT A STOCK LIST OF UDDEHOLM TOOL STEELS?

UDDEHOLM, 155 East 44th St., New York 17, N.Y.

Please send me_____tool steel stock lists.

NAME_____

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UHB

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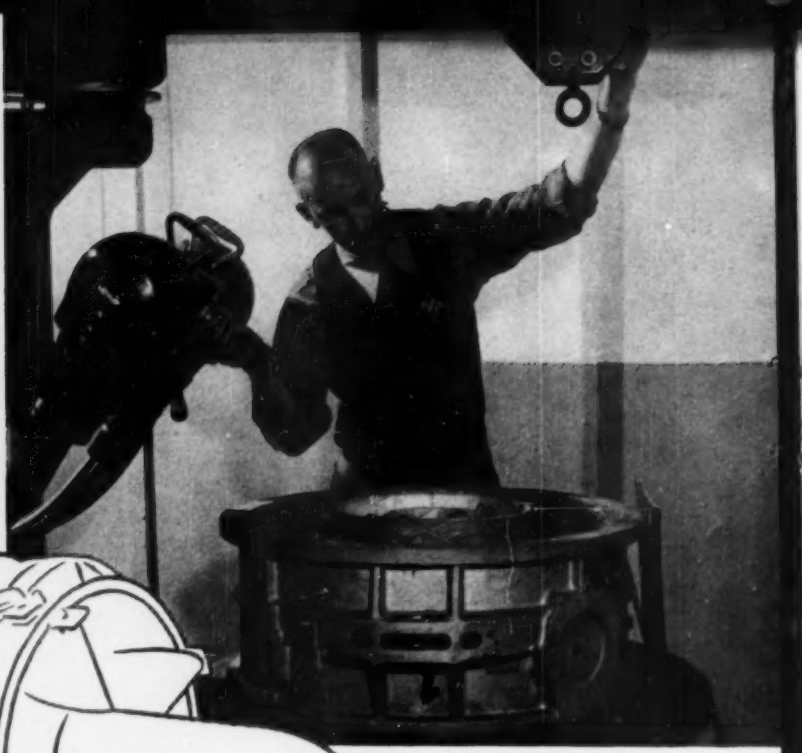
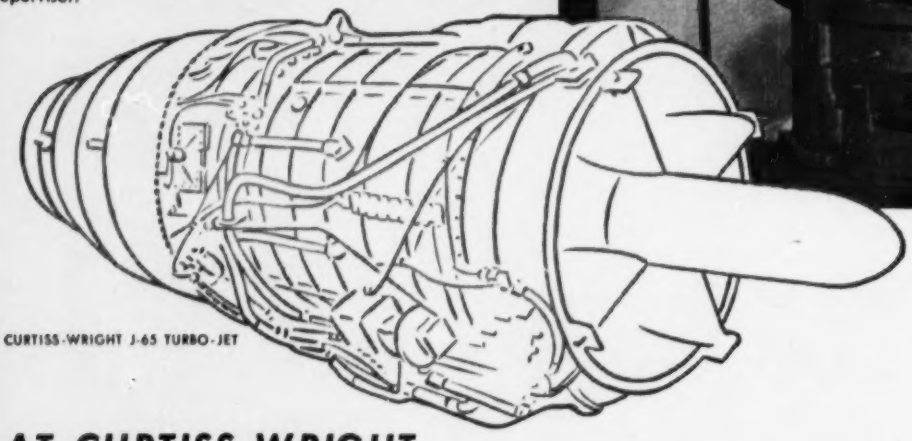
Los Angeles: 5037 Telegraph Road, ANgelus 2-5121

X-ray of oil distributing ring for Curtiss-Wright Turbo Compound engine is inspected by William R. McCarthy, Radiographic Unit Supervisor.



Ted Bienick, Senior Radiographic Technician, aligns tube head for shot of front main bearing support housing of Curtiss-Wright J-65 jet engine.



CURTISS-WRIGHT J-65 TURBO-JET

AT CURTISS-WRIGHT...

Du Pont 506 N.I.F.* speeds handling, improves interpretation of jet component tests

For jet engines producing the tremendous thrusts required to achieve supersonic speeds, castings must be flawless. That's why Curtiss-Wright, one of the world's largest aircraft-engine producers, uses x-ray testing to check casting quality. At the Wright Aeronautical Division, tests are made on Du Pont Type 506 N.I.F.—because of its easier handling and consistent results.

The box-after-box uniformity of 506 N.I.F. simplifies interpretation of Curtiss-Wright's test films. The blue base cuts eyestrain, and the wide latitude helps solve difficult exposure problems.

In the Curtiss-Wright darkroom, non-interleaved Type 506 is a big time and space saver. It takes up only 60% of the storage space required by conventionally packaged films. There's no clutter of interleaving paper. Holder loading is faster, too—an important factor in high-volume production.

Like Curtiss-Wright, you can speed your handling and simplify your interpretation by specifying Du Pont Type 506 N.I.F. the next time you order. It's available in 100-sheet boxes in all standard sizes. When you need technical aid, contact your Du Pont Technical Representative or write the nearest Du Pont District Office or: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada Limited, Montreal.

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*N.I.F.—Non-Interleaved Film, made only by Du Pont.

DU PONT
X-RAY
PRODUCTS

X-RAY FILM • CHEMICALS
"PATTERSON" SCREENS

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

save on SOS stainless

...with a sure Source of Supply

You can be sure of economy and efficiency when you place your order for stainless steel with G. O. Carlson, Inc. Skilled craftsmen working with the finest equipment produce stainless steel plates to the highest chemical industry standards and deliver them to you *on time.*

STAINLESS STEEL PLATES rolled to almost any size or thickness, $\frac{3}{16}$" and heavier, solid or clad, or cut to your individual requirements—whether rectangles, circles or special patterns. Large tonnage of HRAP finished plate carried in stock for prompt shipment. Illustration shows one of our many plate storage racks.

STAINLESS STEEL HEADS press formed or spun in a wide range of sizes and gauges to ASME and Standard specifications. A portion of the stainless steel heads storage is shown above.

STAINLESS STEEL FORGINGS and SPECIAL PATTERNS—Specialized equipment provides flexibility in the production of flanges, circles, rings, sketch plates and other specialties cut or machined from plate, or forged and rough machined.

Also STAINLESS STEEL BARS and SHEETS (No. 1 Finish)

Write for Carlson Weekly Stock Lists. Call on us for complete information about Carlson's services in stainless steel.

Stainless Steels Exclusively

G. O. CARLSON, INC.

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

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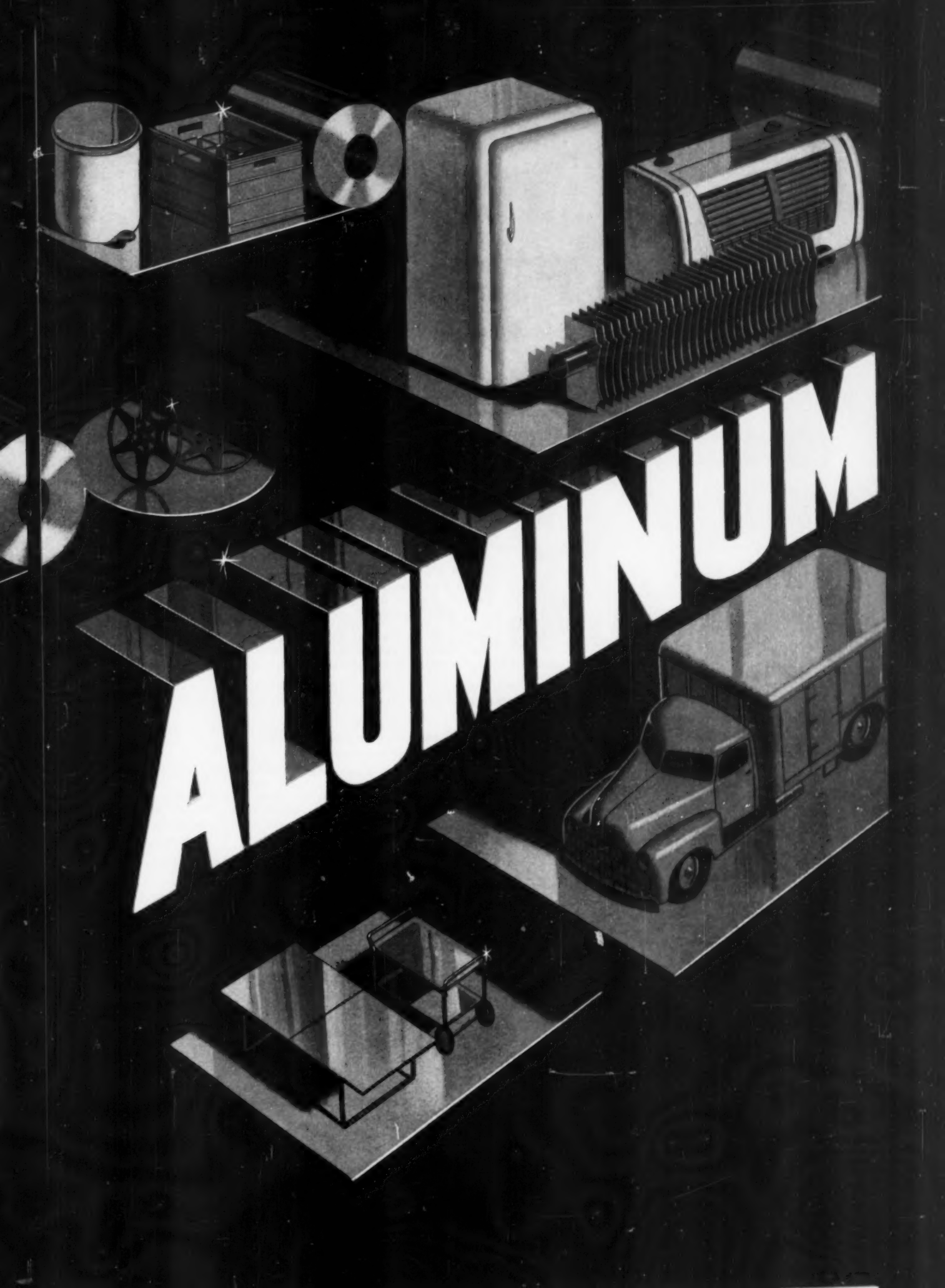
Today . . . competition-minded manufacturers on all sides are finding logical new reasons to use more and more aluminum sheet products. Aluminum's ready workability, corrosion resistance, strength, ease of welding and joining, and the way it lends itself to surface finishes of distinction—all very often combine to make it first choice in metals.

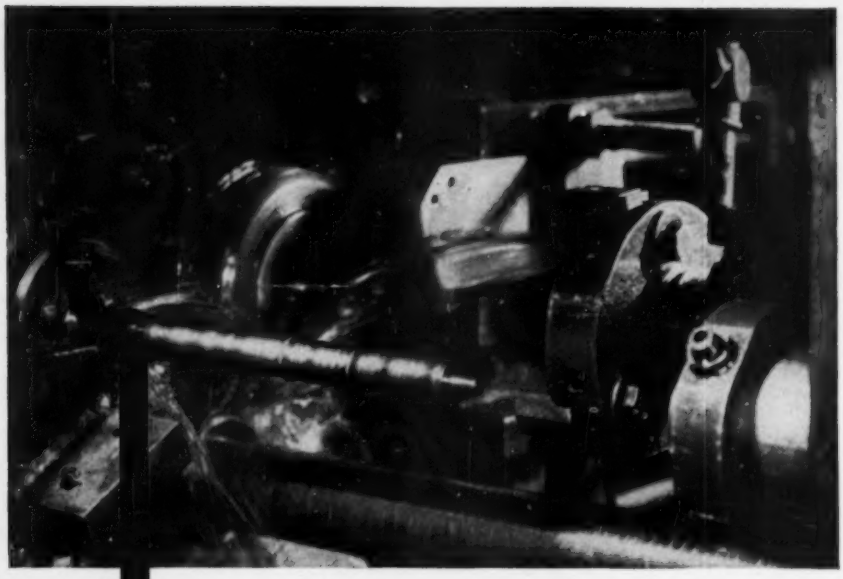
Revere can supply you, not only with a full line of aluminum sheet products, but with aluminum tube, extruded products, electrical bar, forgings and rolled shapes of the finest quality. Added to these are Revere's renowned copper and brass products which have been staples of American industry for more than 100 years.

REVERE KNOWS ITS A-B-C's

ALUMINUM BRASS COPPER

Why not add the Revere A-B-C's to your own alphabet of manufacturing knowledge and experience? Call Revere NOW. Revere Copper and Brass Incorporated, *Founded by Paul Revere in 1801*, Executive Offices: 230 Park Avenue, New York 17, N. Y.


ALUMINUM



How to make duplicate stainless steel parts economically

Make them out of ENDURO Stainless Steel Cold Drawn Bars. Then you get high production rates from your automatics, plus all the high physical and chemical properties you want from stainless steel.

Here's how one manufacturer does it: Edward Valves, Inc., East Chicago, Ind., makes a new MUDWONDER Valve used in the oil fields. It must have high resistance to corrosion and long life.

Valve stems are made of ENDURO Cold Drawn Types 410 and 416. And Edward methods engineers say they get good production for these reasons:

1. **High speeds and feeds can be used**
2. **Surface finish is excellent**
3. **Tool life is longer, down-time for re-grinding is less**

You can have these same advantages in your stainless steel parts, by specifying ENDURO Cold Drawn Bars. And Republic metallurgists will be glad to help you choose the right grades for best production on your present machines. Write to:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
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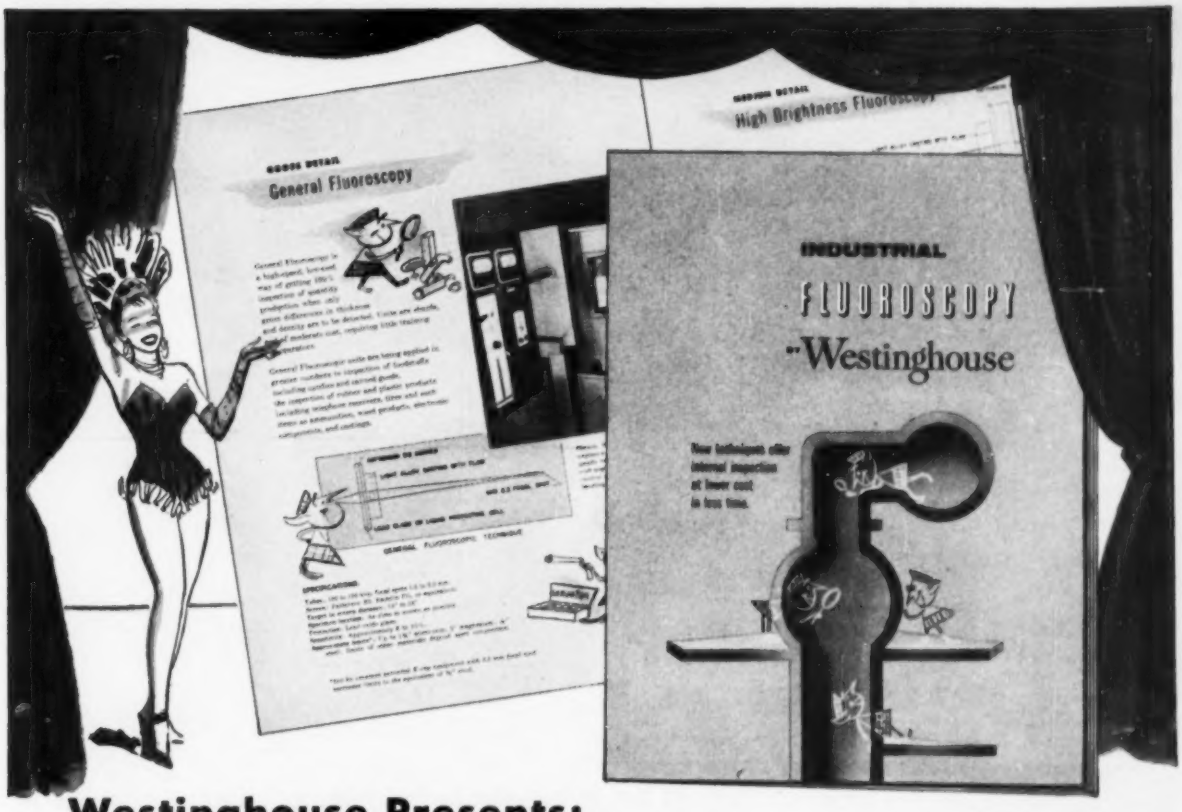
Export Department: Chrysler Building, New York 17, N. Y.

REPUBLIC ENDURO FREE-MACHINING STAINLESS STEEL

REPUBLIC STEEL

Other Republic Products include Carbon and Alloy Steels — Titanium — Pipe, Sheets, Strip, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing



Westinghouse Presents:

Industrial Fluoroscopy

Cheaper, Faster Internal Inspection

Westinghouse has lifted the curtain on its newest aid to industry: INDUSTRIAL FLUOROSCOPY, a twelve-page color booklet that explains and illustrates the uses of fluoroscopy for non-destructive internal inspection.

INDUSTRIAL FLUOROSCOPY carries full information on the three methods of fluoroscopic testing: General Fluoroscopy for gross detail, High Brightness Fluoroscopy for medium detail and High Definition Fluoroscopy for fine detail. In addition, INDUSTRIAL FLUOROSCOPY explains and illustrates the Fluorex Image Amplifier – a useful accessory that may be used with any of the above methods to intensify image brightness more than 200 times.

If you are looking for a practical, economical way to solve your internal testing problems, send for this descriptive booklet today. Fill in and return the coupon below, or call your local Westinghouse X-Ray representative.

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Yes, I am interested in INDUSTRIAL FLUOROSCOPY! Please send me my copy.

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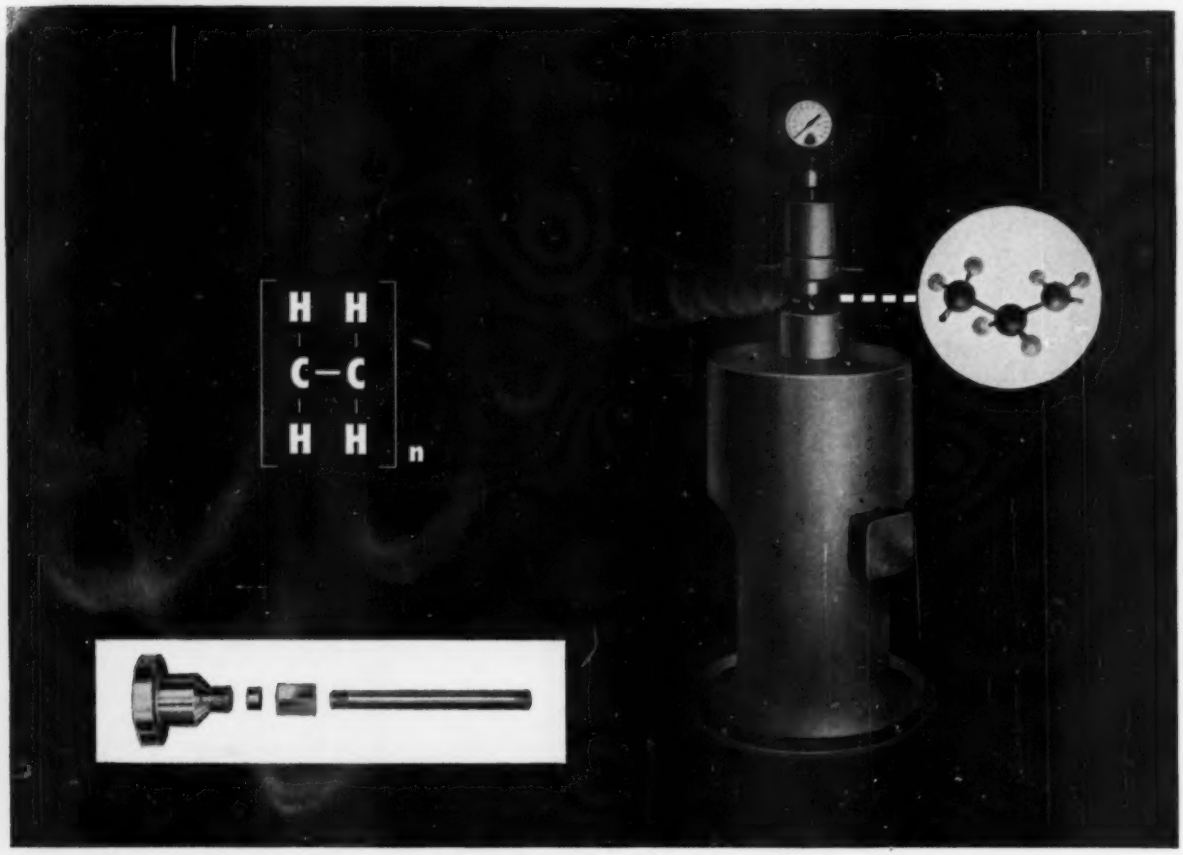


TUBING BY SUPERIOR SAVES 33%
on production cost of Autoclave covers!

Shown here is the Magne Dash* autoclave, a "dash pot" used to test physical and chemical properties of materials under high pressures.

The Magne Dash cover now costs far less to make than it used to. For in redesigning it, Autoclave Engineers, Inc., Erie, Pa. found that Superior cold drawn Type 316 stainless steel tubular component gave them amazing economies. Savings 33%.

Originally, 2" stainless steel forgings were used in the Magne Dash cover. These had to be machined and deep drilled—time-and-money consuming operations. Superior tubing eliminated this expensive work and reduced scrap loss almost to zero! At the same time, minimum yield strength was raised from about 40,000 psi to 100,000 psi. And Autoclave Engineers found Superior tubing easy to thread, easy to clean and unusually resistant to corrosive catalysts used in testing.

If you have a problem in high pressure processing—or any other problem that involves tubing—call on Superior. We make a specialty of fine tubing—in special shapes and sizes—and in more than 55 analyses! Out of our long experience, you are sure to get the answers you want. Tell us about your current production problem. Send for our free Catalog Section 20 on stainless steel tubing. Superior Tube Company, 2008 Germantown Ave., Norristown, Pennsylvania.

*Licensed by Standard Oil Company (Indiana) U.S. Patents 2631091 and 2661338

Round and shaped tubing available in Carbon, Alloy and Stainless Steels; Nickel and Nickel Alloys; Beryllium Copper; Titanium; Zirconium

Superior Tube

The big name in small tubing

All analyses .010" to ½" O.D.
Certain analyses in light walls up to 2½" O.D.

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

Basic Materials

FOR A MILLION PRODUCTS

Alloy Wire, Rod and Strip . . .

Design Engineers are taking advantage of the outstanding mechanical and electrical properties and excellent formability of Alloy Wire, Rod and Strip. Results: Better products, smaller and lighter products, products that are more corrosion-resistant, more heat-resistant, more attractive —and more economical.

Alloy Metal Wire Division can supply you with high quality wire, rod and strip in Stainless Steels, Nickel Alloys and Electrical Resistance Alloys. Why not put these versatile materials to work for you?

SEND FOR FREE HANDBOOKS TODAY

FOR A BETTER DESIGN...
Use Wire, Rod, & Strip

FOR BETTER PRODUCT PERFORMANCE... *Use Alloys*

Among the alloys we fabricate, you will surely find one with just the right combination of properties for your specific application. And you can profit from the fabrication advantages and material cost and weight savings of wire, rod and strip parts and assemblies. Select the alloy you need from these three functional groups:

STAINLESS STEELS—

Alloy Metal Wire Division can provide you with more than 20 different grades of stainless steels. These include the chromium-nickel Austenitic grades with their outstanding corrosion resistance and good mechanical properties; the high chromium Ferritic grades with their high heat resistance, corrosion resistance, and outstanding cold working properties; and the lower chromium Martensitic grades which can be heat treated to obtain exceptionally high strength and hardness in addition to good resistance to corrosion and high temperatures. Stainless steel Wire, Rod and Strip are used extensively for high strength and corrosion-resistant fasteners, springs and mechanical parts and for welding wire, woven and knitted wire parts, and many other applications.

NICKEL ALLOYS—

A wide variety of Nickel alloys are also available for hundreds of electrical and mechanical applications. The excellent electrical characteristics of nickel are especially advantageous for electronic tube parts, such as grids, cathodes, support rods and pins. Monel, because of its excellent corrosion resistance and good mechanical properties, is also used for many mechanical parts, fasteners and springs.

Inconel provides the valuable combination of outstanding heat resistance, corrosion resistance and high strength required in many applications.

RESISTANCE ALLOYS—

Five grades of electrical resistance alloys are now in production in wire, rod and strip form. These are: Alray A—20 Cr, 80Ni; Alray C—15 Cr, 62Ni, bal Fe; Alray D—18 Cr, 35Ni, bal Fe; Excalor—45 Ni, 55 Cu; and Ni—Fe alloys.

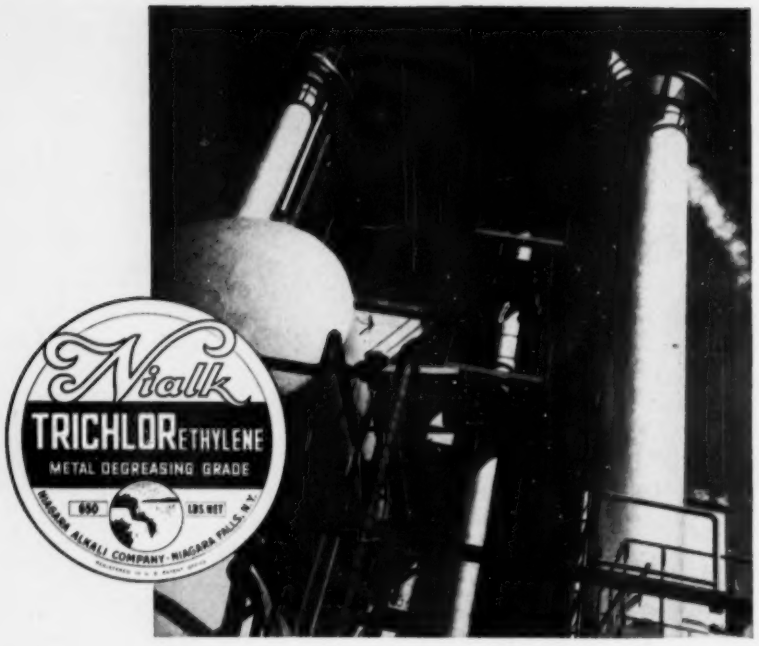
These high quality alloys find extensive applications in the electrical and electronic fields.

SPECIAL WIRE SHAPES—

You can cut costs and improve product performance with Alloy Metal's Special Shaped Wire. Almost any cross-sectional shape can be made on our wire drawing equipment. These shapes can save you tons of metal and many hours of machining time. Shaped wire can be held to close tolerances and has a smooth, tough, flaw-free surface.

ALLOY METAL WIRE DIVISION
H. K. PORTER COMPANY, INC.
of Pittsburgh
PROSPECT PARK, PENNSYLVANIA

2



GET FAST DEGREASING AND SAVE MONEY with NIALK® TRICHLORethylene

(Nonflammable, stable, completely reusable)

In terms of low cost and quick action, you'll find Nialk TRICHLORethylene beats anything yet for leaving metal parts clean, warm and dry, ready for surface treatment.

Take Nialk TRICHLORethylene's low boiling range for example. It is 86.6°C—87.8°C, based on standard ASTM tests. That means quick vaporization. Together with its low specific heat (less than ¼ that of water), you'll have a solvent that really cuts fuel costs.

You'll save money on Nialk TRICHLORethylene's high vapor density too, (4.5 times that of air) because a proper level will be maintained at all times in the degreasing machine. Result: more efficient cleaning with low solvent loss.

Nialk TRICHLORethylene is nonflammable at room temperature. There is no worry about fire when you take the ordinary precautions required in the handling of any chlorinated hydrocarbon.

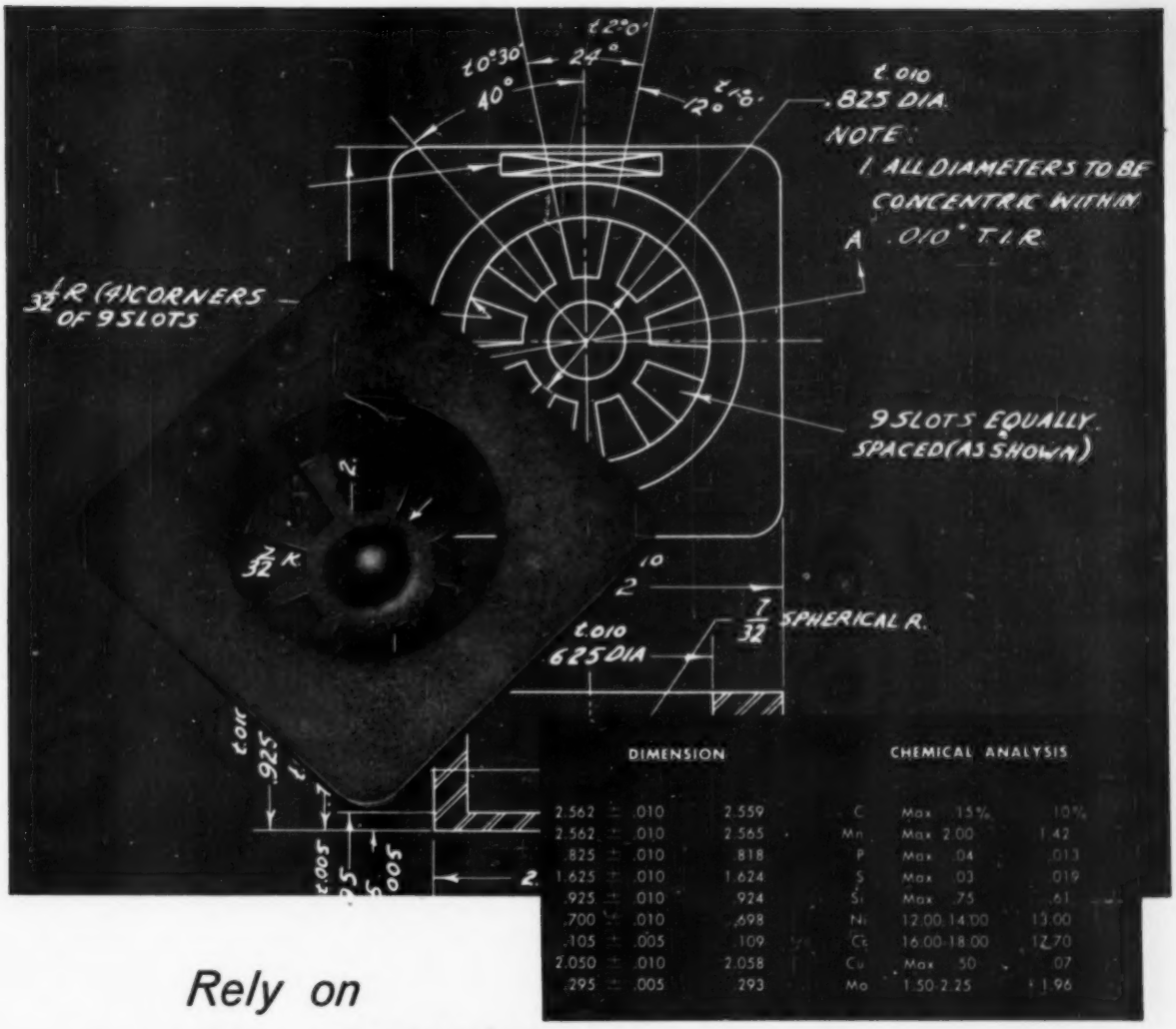
Nialk TRICHLORethylene is stable and completely reusable. And whether you use a carload or a drum, there's no extra premium for TRICHLORethylene's top quality.

Try Nialk TRICHLORethylene for your degreasing operation. On tough jobs like waxes, oils, tars, gums and even metal chips, you'll find it does the job quickly, thoroughly, safely and economically. We'll be happy to send you further information in terms of your own application.

NIAGARA ALKALI COMPANY

60 East 42nd Street, New York 17, New York

NIALK Liquid Chlorine • NIALK Caustic Potash • NIALK Carbonate of Potash • NIALK Paradichlorobenzene • NIALK Caustic Soda
NIALK TRICHLORethylene • NIAGATHAL® (Tetrachloro Phthalic Anhydride)



Rely on

Crucible ACCUMET investment castings

for dimensional and metallurgical accuracy . . .

This intricately shaped aircraft instrument part had to be held to rigid specifications both in size and in chemical analysis of the steel.

That's why Crucible ACCUMET® precision castings were used. For Crucible's *lost wax* method of casting, and its long experience as the country's leading producer of fine special purpose steels, combine to bring you accurate castings of the highest quality. But the two tables shown below actually tell the story better than words can. They show how closely ACCUMET castings are held to original specifications.

The next time you have a job where quality and close tolerances are needed, be sure to investigate the advantages of ACCUMET precision castings – *call Crucible.*

CRUCIBLE

first name in special purpose steels

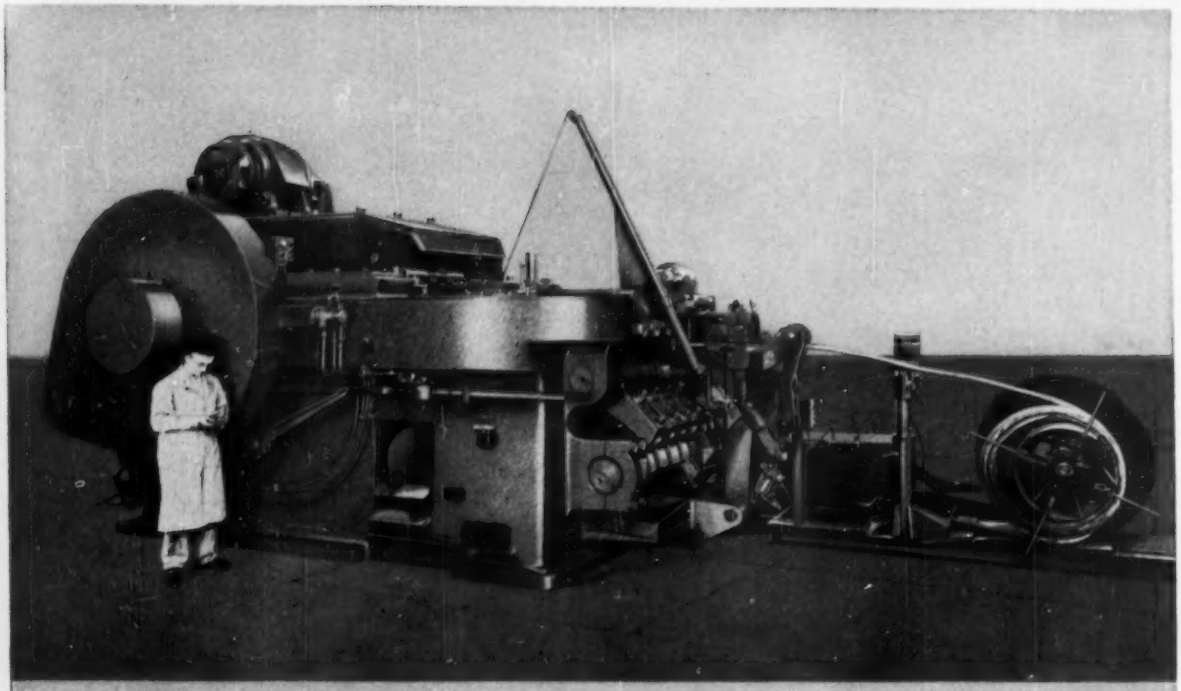
54 *years of* Fine *steelmaking*

ACCUMET INVESTMENT CASTINGS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MAX-EL • SPECIAL PURPOSE STEELS

Canadian Distributor — Railway & Power Engineering Corp., Ltd.



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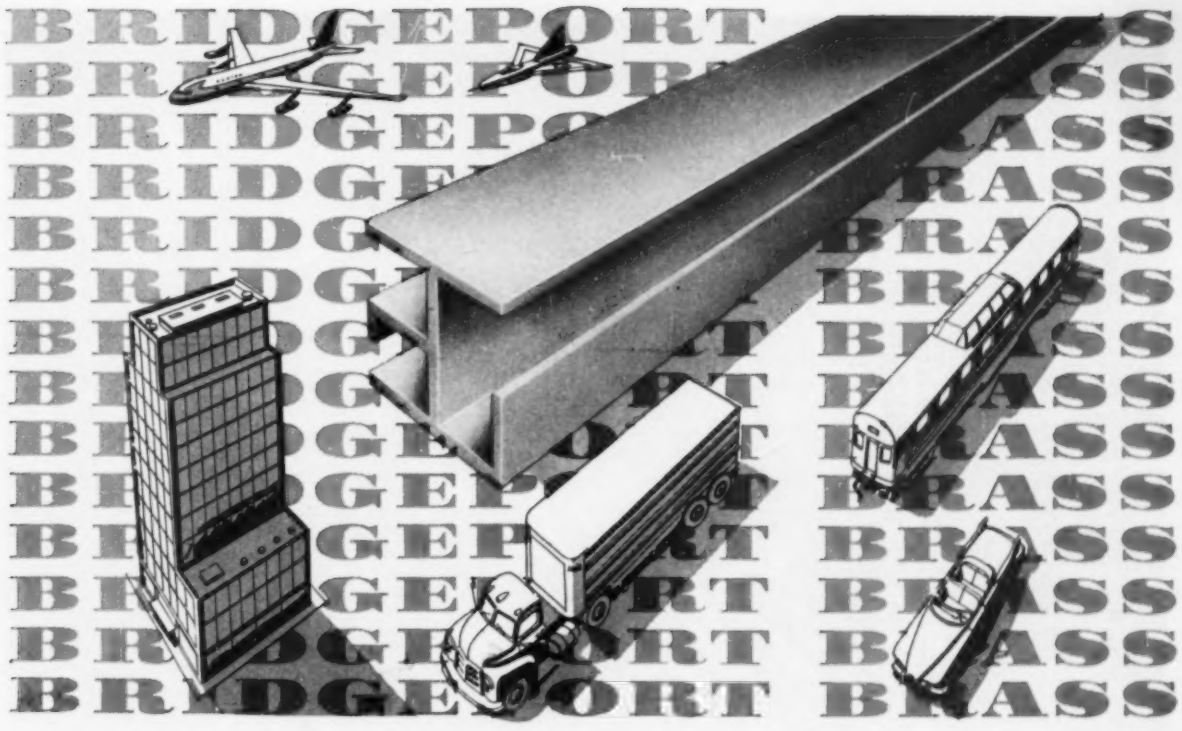

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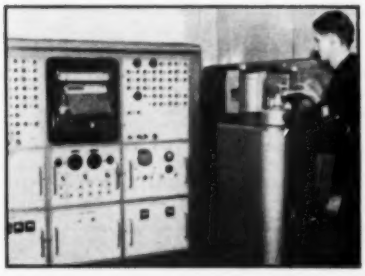

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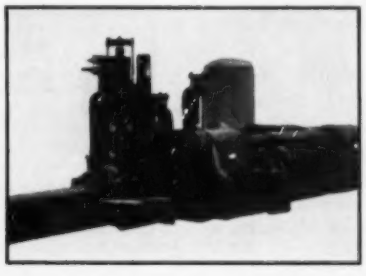

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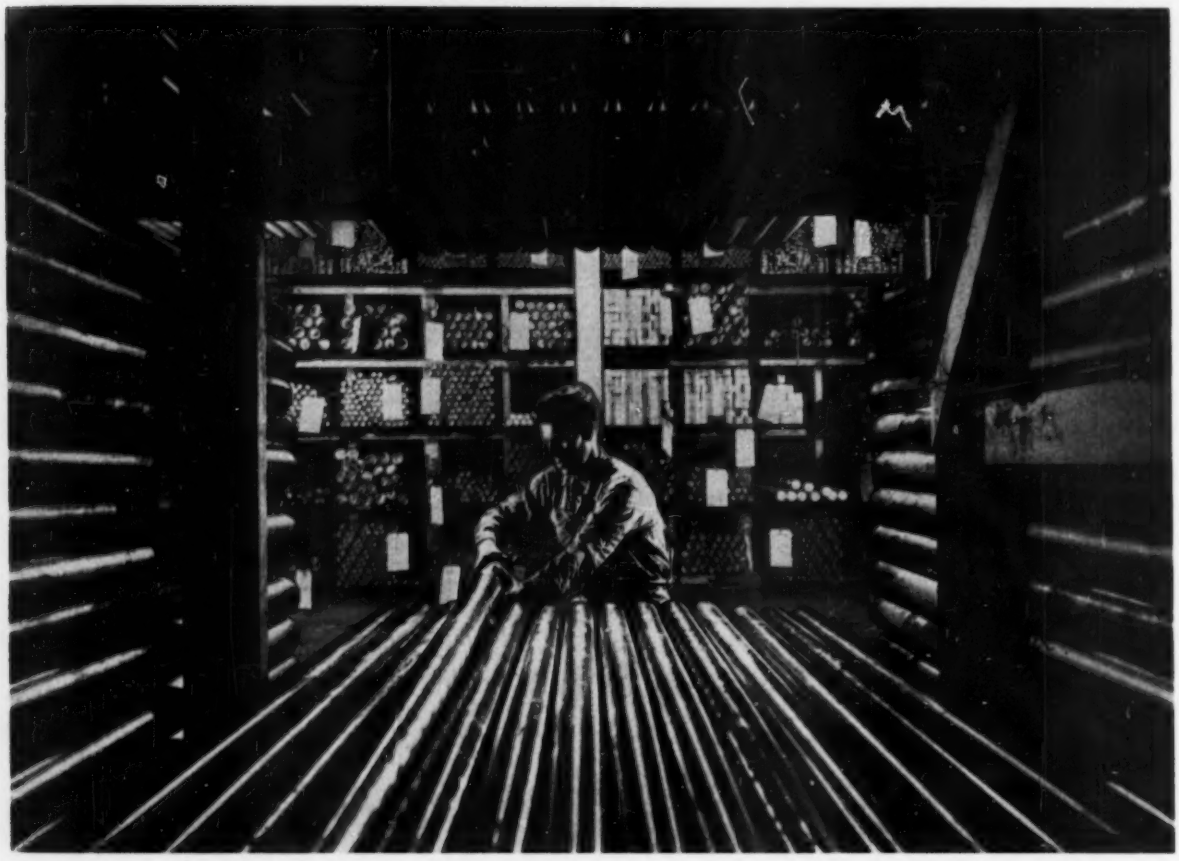

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The

A. S. M. of Tomorrow

From the report of William H. Eisenman, Secretary of the American Society for Metals, presented at the annual meeting of the Society, Palmer House, Chicago, Nov. 3, 1954.

I AM deeply grateful for the distinguished honor the members of the American Society for Metals have bestowed upon me in electing me for the 19th consecutive two-year term as your Secretary. The 36 years already served have prepared me, I feel, to take a look into the metallurgical world of tomorrow—and, from my experience and my faith in the future of the A. S. M., to present to the Board of Trustees and to the membership a plan of progressive, dynamic expansion and progress safely within A. S. M.'s splendid economic capacities.

So, if I may have your indulgence for a few minutes, I will unfold to you the new fields of activity the Society is prepared to, and, in my humble judgment, should, enter. Here is a forward look towards the American Society for Metals of Tomorrow.

ONE MAY state there are two paths of future action open to the American Society for Metals. Here they are:

1. To continue and improve if possible (and it undoubtedly is) the services that are at present provided for its 24,000 members. While such an operation may seem satisfactory at the present time, and while, in some places, the present services of the A. S. M. have called forth commendations, nevertheless such a path presents an uninspiring program. It will never fire the members of the Society to great zeal in its behalf but will create, I believe, a contented staff of employees who will be satisfied to carry on in the same old manner, in the same old channels.

If such a complacent scheme of action were established, the members would undoubtedly soon see the A. S. M. fall into a

cut-and-dried rut so frequently observed in other groups—that of being happily satisfied and, even with a feeling of pride, doing the same old things in the same old way, year in and year out.

2. The other possible path of action for the Society would lead with vigor and dynamic progress to new and increased activities to service and serve the engineering field of the great metal industry. The A. S. M. would then soon take its place as the greatest engineering and educational force of its time. It would again show and lead the way to progress.

As I view the A. S. M. of Tomorrow, I cannot imagine a decline or leveling off of its activities. The A.S.M. has never been, and I'm sure never could be, a "status quo organization", but it will be and should be an "A. S. M. On The March". To me there seems to be but one choice:

"Let Us Have Faith—
Let Us Move Forward!"

However, the final decision does not rest with me, but with all my colleagues of the Board of Trustees of the American Society for Metals. I grant it is my privilege and duty to present for their consideration and final decision the broad field of possible future activities of the society as I see them.

The Board of Trustees and all the Past Presidents have quite some time ago been given my views on the future of the A. S. M. They received my recommendations quite cordially and have unanimously approved the first two, and are giving study and consideration to the other three. Plans for placing the first two proposals in operation are under way.

We all know that tomorrow comes very quickly. Therefore, it is important that any progress and advancement planned for now and in the near future must have the reserve capacity for the A. S. M.'s future needs.

So, here begins my word picture of

The A. S. M. of Tomorrow

ONE SHOULD NOT be so busy and occupied with present activities that he fails to recognize the dawn of a new day with new possibilities for increased service and the need for an alert and forward look.

I would not for a moment have you feel that the thoughts expressed on the projected activity here unfolded represent the last word in just how and when they might be placed in operation. The real purpose I have in mind now is to present the broad picture of great possible future usefulness of the American Society for Metals, not to give minute details of its operation, but to show how all the projected activities dovetail into a picture of tomorrow.

The American Society for Metals of Tomorrow, as I foresee it, will be a gradual progression from one phase of accomplishment to the next, an evolution springing from the present firm and substantial base of service—a base created through 36 years of growth and advancing preparation for the tremendous opportunities that should now be attacked with vigor and comprehension.

And here are the phases of the recommendations and proposals I make, with a fuller discussion of each to follow:

1. The erection of an adequate new headquarters building (within two years).

2. The creation of a division of the A. S. M. to be known as the Metal Engineering Institute (in operation within two years).

3. The creation of a division to be known as A. S. M. Metallurgical Seminars (within three years).

4. The creation of a division to be known as the A. S. M. Metal Research Laboratory (as soon as practical!).

5. The creation of a division of the A. S. M. to be known as the Metal Science University (to follow the Research Laboratory).

New Headquarters Building

I WISH to present first a few facts about a new headquarters building.

The necessity for a new headquarters building, as well as a new location, has already been recognized and approved by the Board of Trustees. The present quarters at 7301 Euclid Ave. in Cleveland are externally and internally attractive but inadequate in size and undesirable as to location, due to business neighbors, the surroundings, and also the personal safety of employees and property. Also, the present site and buildings are economically unsound.

The site and headquarters building fund, including the appropriations already made, and exclusive of all other assets of the Society, now total $500,000, and it is expected that by the time the building location and plans have been approved, the fund will total more than one million dollars. A committee is now actively searching for a site, either within city limits of Cleveland or in a suburban area which would be easily accessible and where the value of the land has not been inflated, but has every prospect of a very substantial increase in value.

A. S. M. Metal Engineering Institute

THE SECOND step in the March of Metallurgical Progress is the creation of a division of the American Society for Metals to be known as the A. S. M. Metal Engineering Institute. I am pleased to report that this forward-moving activity has already received the unanimous approval of the Board of Trustees.

Metal Engineering Institute is the tentative name that has been assigned to that division of the Society which will have control of the preparation, manufacturing, presentation and administration of the Educational Courses now being written by carefully selected high authorities on the 41 metallurgical and metals engineering subjects so far scheduled for production.

Work on these Educational Courses has been in progress for about a year, during which time the invited authors prepared extended outlines of each of the 15 chapters of their course. After conferences with each author in Cleveland to discuss his outline and the general form for presentation of the subject material, 38 of the 41 subjects are now being written and will be completed within 12 months. The authors have been enthusiastic about the entire plan and have been most happy to cooperate in this outstanding educational activity. Consequently, it is hoped that within 18 months, the Metal Engineering Institute should be ready for presentation of the 41 Educational Courses to be used for

1. A. S. M. Chapter Educational Courses.
2. In-Plant Training.
3. Correspondence (Home Study) Courses.

1. The A. S. M. Chapter Educational Courses—A Chapter will be able to select the lessons (three to six or more) of greatest interest to its members. This will give a Chapter greater flexibility in the selection of subjects, since it relieves the lecturer of the necessity of preparing lesson material. The committee could select a group of lecturers from one A. S. M. Educational Course, or (since each of the 15 lessons in a course is a complete unit) the committee could select individual lectures (lessons) from a number of courses. The availability of these educational courses will greatly increase the educational activities of the A. S. M. Chapters, give them an opportunity for greater service, and enhance the Chapters' local stature in many ways.

2. In-Plant Training—We are all aware of the great extent to which this type of training is being sponsored and the importance attached to it by the metals producing and fabricating industry. While some of the larger companies are staffed to do this in-plant training, there are literally thousands of plants that either do without it, or must depend on an outside source for this service. And where, one might ask, would they be most apt to turn, but to the A. S. M., the Engineering Society of the Metals Industry?

3. The Correspondence (Home Study) Courses—The "typical" student will be a young man, possibly between the ages of 24 to 31, married, a high-school graduate who went into Service, then to work, and is at present employed in the metals industry, either in production, fabrication, testing, or in some specialized investigation (such as corrosion, high-temperature alloys, and so on). The type of metal industry in which he is engaged will vary from the manufacture of earth-moving machinery to airplanes, from transportation to con-

struction, from steel mills to automobiles. This individual may be a young man in any type of manufacture using metal; a man who wants to and should know more about the material or process with which he is working, and why it performs the way it does. The American Society for Metals' courses will supply that information.

The great number of individuals employed in all branches of the metals industry represents a large percentage of the total number employed in the national economy. (The metals industry is about 50% of the present economy). Consequently, the field for home study courses is large—almost unlimited. The opportunity to engage in self-study and self-improvement will undoubtedly have a great appeal for those young men whose ambition and education will play a very important part in their future.

It is reported that some two million Americans are now paying more than $40,000,000 each year to study everything from budgetary control to blue print reading. Enrollment is up 15% over 1952. Today there are more than 40 accredited institutions belonging to the National Home Study Council, yet only two of which together offer four courses in metallurgy! These courses are broad and all-inclusive, and will have no similarity at all to the A. S. M. courses which break down the general courses they offer into over 40 different special subjects or divisions.

Training supervisors for large corporations generally recognize the value of home study. Some firms have contracted with training institutions to take over part of their load.

Today, educators in most schools of the country recognize the need for such off-campus training, since there are currently more students enrolled in home study courses than in all the universities, colleges, professional and vocational schools *combined!*

The Metal Engineering Institute will be self-supporting and should in a very limited time of operation, return many times the modest cost incurred in the preparation, production and presentation of the courses.

Because of the outstanding reputation of the authors, their grasp of the aims, ideals and purposes of each educational course, their acquaintance with the vast group in the metal industry these courses are to serve, I am more than safe in predicting that this division of the A. S. M. will soon grow into the most widely known, recognized and appreciated activity of the Society, fulfilling an important function in and for the metals industry, a service that will become the most valuable and continuing asset we have.

A. S. M. Metallurgical Seminars

THE THIRD step in the program is the A. S. M. Metallurgical Seminars. These seminars will present, continuously throughout the year, intensive one-week and two-week institutes for discussion and study at an advanced educational level of important and current phases of metallurgy and metals engineering. For these seminars will be assembled the top scientists and specialists in the field under discussion. They will constitute informal discussion groups devoted to individual metallurgical problems, as well as refresher courses in metallurgical procedure.

Seminars are becoming increasingly important in providing opportunities for members of organizations to meet together to exchange information, solve common problems, make decisions, bring to participants the results of study and experience in the field under consideration, together with practical application to specific problems. Attendance at these seminars will be limited to insure maximum attention to individual needs.

The A. S. M. Metallurgical Seminars will be in session throughout the year (not confined to the few summer months) and will thus afford a gathering center or forum where metallurgical problems and new information on metals engineering will always be the prime topic for conversation and study.

A. S. M. Metal Research Laboratory

THE NEXT new project for the American Society for Metals, in line with a policy of dynamic expansion, should be the establishment of a metal research laboratory. Properly organized and directed, it would fill an area now unoccupied and perform important functions now neglected, yet of great importance to America's metallurgical advance.

At present, laboratories in and for the metals industry may be roughly subdivided as follows:

1. Laboratories in the individual plant or in a central location of one corporation.

2. Governmental laboratories, such as those of the Bureau of Mines, National Bureau of Standards, Atomic Energy Commission, and at the Army Arsenals. Essentially these are the same as category No. 1 above.

3. Commercial testing laboratories, many of which are doing some development work. However, in metallurgy these are largely confined to inspection and representation.

4. University and endowed (or self-supporting) research institutes, whose work is principally an extension of that listed in categories No. 1 and 2 upon well-defined problems beyond the manpower or instrumentation available in the sponsor's own laboratory.

5. Laboratories for fundamental research, of which there are not very many—although there is a very good example in the University of Chicago's Institute for the Study of Metals.

Such a review, even though very brief, indicates one important field now all but completely neglected. Categories No. 1, 2, 3, and 4 work on *ad hoc* or practical problems of limited scope, designed to benefit a limited public.

Category No. 5 is working at the advanced frontiers of knowledge.

The gap between these two represents the field for the A. S. M. Metal Research Laboratory—namely, industrial problems in metals of widest generality, useful either to the whole metals refining industry, or to the whole heat treating industry, to the whole super-power industry, and so on. Since there is nothing like it in America now, one would have to go abroad to find parallels of laboratories studying the main problems of whole industries, such as the British Non-Ferrous Metals Research Association, the French Iron and Steel Research Institute (IRSID), Centre Technique des Industries de la Fonderie, or the Swiss Watch Industry's Central Laboratory. In the United States we might have to go back as far as the 1920's and cite A. S. M.'s Past President Charles Herty's study of open-hearth steelmaking processes at the Pittsburgh Station of the Bureau of Mines, financed by practically all the firms in the steel industry. In all these examples much work is done in the cooperating plants, thus avoiding installation of heavy equipment of mill type.

In brief, an American Society for Metals' research laboratory—with the objective of solving general problems concerning the use, and improvement and application of metals in American industry—would not be competing with existing effort, but would in fact fill a great gap in American metallurgical research.

When such an A. S. M. Metal Research Laboratory becomes a working organization it would naturally attract the type of problems it is equipped to handle. Undoubtedly it would be called upon, not only to serve the metals industry, but in case of emergency, may well serve the nation.

While the scale of activities in the A. S. M. Metal Research Laboratory would largely depend on the number of research programs devised by the laboratory director, it could also receive direct support from the American Society for Metals Foundation for Education and Research, and from the American Society for Metals itself.

Metal Science University

WITH THE A. S. M. Metal Engineering Institute, the Metallurgical Seminars and the Metal Research Laboratory in operation, the fifth phase of my proposal follows as a natural sequence—the creation of a division of the A. S. M. to be known as the Metal Science University.

The top metal scientists, engineers and researchers will be attracted to and become a fixed part of this great assembly of metal men. Their teaching talents and instructional abilities will be fully made use of in the classrooms and laboratories of the University.

Differing from other institutions, it will offer courses in metal science only, beginning with the third year students and continuing through the post-graduate studies. Special care will be given to the training of research workers so the graduates may help fill a void that is now developing. The graduates should also be capable of going immediately into industry and head a research department, having had training in management and research planning.

I have unfolded my view of The A. S. M. of Tomorrow. It is not a hastily conceived plan, but one towards which the Society has been moving for many years. This forward looking program is no small plan, yet

it is logical and can readily be carried to full fruition if only you have the will and faith to go forward.

While I am pleased to be the author of this expansion program, it is by no means a one-man operation, nor is any one man essential to its gradual accomplishment. There are hundreds of live, energetic and capable individuals who recognize that the A. S. M. should not rest on its reputation, however good it is, but must look forward and advance forward, who can easily take the formula presented here and, with the assistance of all A. S. M. members—the world's largest group of metal scientists and engineers—reach the highest peak of usefulness and service to the metals industry.

If I have expressed my thoughts clearly, you have recognized how this Metal Science Center has grown and expanded in a logical progression—each activity an advance on the frontier of increased educational activities; each one a new service for a great primary industry.

You have already visioned with me the extensive acreage necessary to comfortably accommodate and house the extensive buildings which this progressive expansion of the society will require.

You have recognized, I am sure, that as the present A. S. M. has been successful in giving extensive service to its members at a minimum cost and has, at the same time, created a firm financial structure, The A. S. M. of Tomorrow, as I have outlined it, will continue as a successful, self-sustaining organization, with all divisions helping one another so that in a smooth operating Society the net result can only be a continuous and increasing service by all of the divisions of The A. S. M. of Tomorrow.

Make No Little Plans

I COMMEND this program to you. It is no little plan. I hope you believe, as I do, with the eminent architect Daniel H. Burnham who said:

> "Make no little plans; they have no magic to stir one's blood and probably themselves will not be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever growing insistency."

Remember; let A. S. M. make no little plans! Let A. S. M. make only big plans, realizing that vision is indispensable to progress. I have presented this diagram of The A. S. M. of Tomorrow so that it may be recorded and made a part of the official record.

You, the members of the Society, and the Board of Trustees, and all of us can fill out that diagram in every phase—and when it is completed, it will be a more finished and successful achievement than could possibly be created by a word picture of the most glowing eloquence. But to create and accomplish, we must have faith in the American Society for Metals as an instrumentality through which all of us, recognizing that the security and welfare of our civilization depend increasingly on the advancement of scientific knowledge, will have an opportunity to serve humanity, our industry, and our country.

Hear A. S. M.'s call to greater service.

If we listen and hear the call,

And answer with a will and determination,

No barrier can halt the progress of The A. S. M. of Tomorrow.

Metal Progress
Volume 66, No. 6 December, 1954

Continuous Melting and Casting—Bit by Bit

IT SEEMED strange to the Editor to find a steelworks in a boiler factory. Of course "boiler factory" doesn't exactly describe the M. W. Kellogg Co.'s huge plant in Jersey City, where all sorts of pressure vessels, power plant, chemical and refinery equipment are made. Nevertheless here is where a whole series of developments have been made by R. K. Hopkins, culminating in an Electric Products Dept. which produces ingots of jet engine alloys, leaded stainless steels, toolsteels to size and analysis as ordered.

The whole thing originated at least 30 years ago when the petroleum industry started using "sour" crudes. Before that, a still would be made of firebox steel and an eighth-inch added for five years of corrosion. Sour crudes changed all that; allowances for corrosion grew and grew until slabs 6 in. thick were demanded—past the limit of forge welded seams, then used. Hopkins (then director of research) decided that the situation could be met by plain steel of moderate thickness—enough to carry the pressure—clad with a relatively thin layer of corrosion resistant alloy; but how to make this composite plate, with layers thoroughly bonded together, was another thing again.

It was solved with characteristic boldness. A carbon steel slab was set on end and a trough-like mold fixed on one side of it. Into the thin, channel-like cavity between slab and mold played

several welding heads, using consumable electrodes of proper analysis. These were moved continuously to and fro, so the slot would be gradually filled to the very top, whereupon the mold would be removed and there was a composite ingot ready for the plate mill. (This process, by the way, has been used for 14 years by Allegheny Ludlum Steel Corp. for its "Pluramelt" stainless-clad sheet.)

This scheme is not quite so simple as it appears. It is relatively easy to get enough heat through the electrodes to keep the top of the rising pool of metal molten, but auxiliary nonconsumable electrodes playing on this pool were needed to raise its surface horizonally to the very edge and fuse it into the slab's surface. Likewise an extensive study of protective slags had to be undertaken.

Once these auxiliary problems were solved, they in turn became the basis of a very popular method of "hot topping" ingots of toolsteels and other specialties. As observed by the Editor at Latrobe Steel Co.'s plant a couple of years ago, each squat square ingot of toolsteel, after teeming, is covered with a powdery conductive slag, and an electric arc struck between water-cooled electrode and hot steel below. (Each of the 30 molds is served by its own Lincoln arc welding generator.) Energy from this source keeps some of the metal molten, without using refractory hot tops, and thus any pipe is satisfactorily fed.

These two commercial developments obviously held the essentials of a third—at least so Hopkins told himself and the Kellogg management. This is an "electric ingot process", wherein the entire ingot is formulated through an electric arc. A coil of low-carbon strip steel, perhaps 3 in. wide by 1/16 in. thick, is fed through a set of tube-forming rolls; the resulting tube is the electrode. The arc from its end is submerged in a 4-in. layer of molten slag, and the other ingredients for the required analysis (such as nickel shot, crushed ferrochromium and ferromolybdenum) are fed through the tubular electrode directly into the focus of heat. The water-cooled ingot mold is lowered gradually in synchronism with the rolls which form the electrode and with the alloy metering devices so the elevation of the liquid is held constant. A thin, uniform layer of slag freezes against the mold wall; this "egg shell", as the workmen call it, is the real mold. Ingots up to 12 in. diameter, short or long, can be made in this way; larger diameters require additional heat from auxiliary electrodes (nonconsumable). Production may be changed to ingots of another analysis merely by resetting the alloy metering devices and the electrical controls. In fact, transition pieces from Cr-Mo steel to stabilized 18-8 have been made by starting a small ingot with the low analysis and then gradually adding nickel and chromium. Nickel-base alloys obviously use nickel strip for the electrode. Capacity of a single machine is 30 lb. per hr.; electrical consumption is 1000 kw-hr. per ton (compared with 800 for good arc-furnace practice).

At first thought, the metal from such a machine would be expected to be anything but uniform. However, Hopkins says that variation in chemistry, edge to center, end to end, and ingot to ingot, is not much more than the analytical accuracy. Apparently alloying is practically instantaneous and complete; solidification follows a short time thereafter, exactly in step with the metal coming into the system. Furthermore, such nonmetallics as exist are so thoroughly dispersed that sectioned and etched forgings show none of the characteristic fiber or flow lines. Better, directional properties are remarkably uniform, and elongations (ductility) of metal originally at the axis of the ingot are remarkably high. No segregates also make for better machinability.

Mr. Hopkins, you have something there!

A Thought on the Oppenheimer Case

"The Republic," said the revolutionary judge who condemned Lavoisier to the guillotine, "has no need for learned men."

Searching the Literature Automatically

With W.H.E. and M.R.H. (shop talk for Wm. H. Eisenman, secretary of the American Society for Metals, and Marjorie R. Hyslop, editor of the *Review of Metal Literature*) to Battelle Memorial Institute in Columbus and a long powwow about the mounting cost of keeping abreast of scientific literature. Walter Crafts of Union Carbide & Carbon's research laboratories was also there and he believes that entirely too much time is now required to search the literature when a new metallurgical problem arises. Furthermore, an adequate job requires a man of broad experience if he is to recognize interrelationships of topics and important auxiliary items, but since the undoubted future trend is toward research personnel of lower age (and narrower

experience), some means must be devised whereby searches can be made by machine of cards or tape on which the citations are coded in such a way that synonyms and collateral items will be spotted by the machine itself.

Clyde Williams, director of Battelle, pointed to another almost-criminal waste in valuable man-hours and duplication of effort in laboratories both in the U.S. and Europe where similar or overlapping library searches are made—a waste which could be avoided if a central depository of coded cards were available, well advertised, and widely used. A long step toward meeting this situation is being taken by Battelle. Working in conjunction with manufacturers of automatic electronic machines, Battelle is developing systems for analyzing, coding, and searching literature. Specially designed equipment can be put to work on *Review of Metal Literature* as the items are abstracted and—if funds are available—the published store of items can also be coded so that by 1960 the 1950-1960 decade will be ready for machine searching, by 1965 the 1945-1965 period. It would seldom be necessary to reach further into the past than 20 years.

While metallurgical literature, with its 10,000 items yearly, will be a good thing to start on, it obviously does not cover enough ground. *Chemical Abstracts* publishes about six time as many citations annually. Were physics and borderline areas to be included, the total might come to a staggering 100,000 citations yearly. This situation was clearly in mind when Massachusetts Institute of Technology organized a "Center for Scientific Aids to Learning" in 1947, with a grant of $100,000 for three years from the Carnegie Corp. and a total estimated budget of $215,000 for five years. (Research costs money now-a-days!) J. W. Perry, who early joined this project to study indexing methods and coding for machine selection, and who is now on the Battelle staff, said that the machinery about to be delivered would be quite adequate for the metallurgical literature. With it the citations could be transferred to cards so coded that the machine can search a stack of cards and segregate those items which answer a specific problem (for example, "list all articles on annealing 18-8 in H_2"). This identifies the items by serial number and the actual references, abstracts, and original papers are found under these numbers in the storage files. Advances in electronics also foreshadow machines using magnetic tape or photosensitive film which can handle a collection of several million items in a few hours and for a few hundred dollars. An absolute prerequisite would be a code book and list of synonyms and cross references so the code clerk can place correct symbols on cards, tape or film so the machine can operate, and much intelligent work has already been done on such a code book and dictionary of synonyms.

Finally we get down to the $64 question: "How much is the trial run of metallurgical literature going to cost and who will pay the bill?" In addition to the A.S.M.'s costs of producing the present annotations, it will cost about $30,000 a year to keep the machine-fodder current, and another $20,000 to encode a previous year—in round numbers, then, $50,000 a year for 10 years. While that's a large sum of money, it's not so much if it's spread around among 20 sponsors—which certainly could be found among metal producers, large consumers, research institutes, and the electrical and communications industry—to say nothing of forward-looking firms in the chemical, food, and petroleum industries, industrial associations or educational foundations which can see that a solution of the metallurgical literature problem can solve the literature problem in their own and related branches of knowledge.

Once this thing gets started it will really be useful in about three years (when a six-year span of literature can be searched). Several lines of utility can be foreseen:

Large companies could own duplicates of all or any part of the machine record, to which could be added private or unpublished information of their own, and have the machinery to make their own searches.

Literature searches of all or any part of the field could be made by the central depository on a fee basis.

To serve the operating metallurgist in the smaller companies, whose interests are more specific and limited, cards written in plain English could be furnished of all citations, as they appear, in the man's own specialty.

A Scientist's Point of View

One day during the *first* World War, the celebrated British physicist Rutherford is said to have written an apology for not attending a meeting called to discuss a war research problem. He stated that he was too busy with experiments in which he seemed to have split the atom. "If this is true," he wrote, "it is far more important than your War."

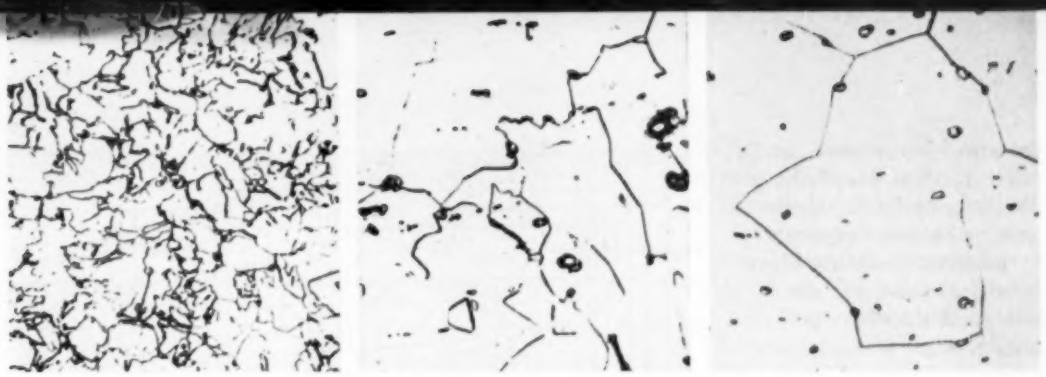
A Low-Alloy, Cr-Mo-Ti-B Steel for Use up to 1200° F.

Cornell Aeronautical Laboratories, under sponsorship of the Materials Laboratory, Wright Air Development Center, U.S.A.F., find that a semicommercial heat of boron-treated 3% Cr, 0.5% Mo, 0.5% Ti low-carbon steel has creep and stress-rupture properties superior to stabilized 18-8, at least at temperatures up to 1200° F. and times up to 100 hr. It should be quite useful for rockets and missiles.

At the 1949 Western Metal Congress held by the American Society for Metals in Los Angeles, George F. Comstock of Titanium Alloy Mfg. Div. of National Lead Co. read a paper calling attention to the remarkably high strength conferred on low-carbon steels by boron and titanium, or boron and columbium. Similar additions of titanium (about 0.30%) and boron (0.02 to 0.03%) similarly strengthened chromium-molybdenum steels, heat resistant chromium steels, and austenitic chromium-nickel steels — all very low in carbon (0.07% or less). Mr. Comstock suggested that a boron-treated low-carbon steel containing about 0.30 Ti would be an improvement on the carbon-molybdenum steels usually put into services at 1000° F., since stress for rupture in 1000 hr. of the two steels is 50,000 and 25,000 psi. respectively. For long service at 1100° F. he felt that the steel should contain about 3% chromium to resist oxidation. Such a steel, again with 0.30% Ti, boron treated, 0.06% C, showed a rupture strength of 30,000 psi. for 1000-hr. life at 1100° F. (The more-or-less standard 0.15% C, 3% Cr, 1% Mo steel has only an 11,500-psi. rupture strength for 1000-hr. life at 1100° F.)

This important paper by Mr. Comstock was printed in *Metal Progress* for July 1949, p. 67 to 71. Evidently, the high-temperature strength is due to *both* titanium and boron. Titanium alone is not of much help. For example the American Society for Testing Materials' recent report on the elevated-temperature properties of chromium-molybdenum steels (Special Technical Publication No. 151) gives the 1000-hr. strength of 5 Cr, 0.5 Mo steel and of 5 Cr, 0.5 Mo, 0.5 Ti as about the same: 10,000 psi. at 1100° F. and 6000 psi. at 1200° F. The combination of the two elements acts to produce a hardened solid solution (acicular in appearance under the microscope) which retains its hardness and hence its strength and creep resistance at high temperatures. Two mechanisms were suggested at the Western meeting. One, by Mr. Comstock, was that quenching from the necessary high temperature (2000 or 2100° F.) produces a martensite which is very stable; in fact tempering at 1000 to 1100° raises the hardness moderately, beyond which softening occurs. The Editor of *Metal Progress* at the same meeting pointed out that those very facts indicated an action more like age hardening; the quench retained substantially all of the carbon, titanium and boron in solid solution in the austenite, and this structure was further hardened by precipitation of insoluble particles when aged (tempered) at temperatures around 1100° F. Further work at Cornell Aeronautical Laboratories, now to be described, seems to support the latter view, although the quenched solid solution is designated as "acicular ferrite".

Since the discovery of this titanium-boron effect by Comstock indicated the possibility of a new low-alloy steel sheet for such high-temperature services as tail cones and combustion chambers for jet engines, the Air Research and Development Command, through the Materials Laboratory, Research Division, Wright Air Development Center, U.S.A.F., contracted for



0.08 C, 0.27 Ti } Ratio 3.4; B-96 | 0.09 C, 0.94 Ti } Ratio 10.5; B-88 | 0.08 C, 1.65 Ti } Ratio 20.6; B-65

Fig. 1 – Change in Microstructure and Hardness as Ti-to-C Ratio in Boron-Treated Steel Increases. Nital etch, 500 ×

further investigation by Cornell Aeronautical Laboratories. Lt. M. A. Piekutowski was project engineer. The results of the study have been published in W.A.D.C. Technical Report 52-77, dated April 1952, and the facts in the remainder of this article are from that somewhat elaborate study. Sentences in brackets [] represent interpolations and interpretations by the Editor of *Metal Progress*.

A considerable number of 30-lb. heats of titanium-boron steel was made in the Titanium Alloy Mfg. Div. laboratory to reveal the influence of variable composition, and a 600-lb. heat of supposedly optimum analysis was made under commercial conditions by Simmonds Saw Co.

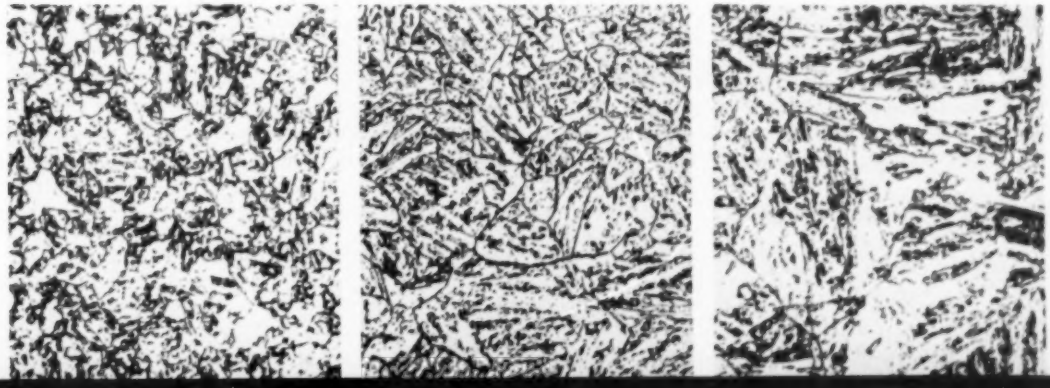
The large heat was melted in an induction furnace and deoxidized by aluminum; ferrotitanium and ferroboron were added and the heat poured into an 8-in. square ingot, 3 ft. high. This ingot was forged to a 1-in. slab about 8 ft. long, and subsequently rolled and cross-rolled to a 0.090-in. sheet about 20 in. wide. All hot work was done at 1850° F. max. Subsequently this sheet was rolled at 1850° F. to thinner gages (0.030 to 0.075 in.) for the various tests. Sound sheet was thus produced with no particular difficulty, and the results of high-temperature tests – creep and stress-rupture – agree with those from corresponding 30-lb. laboratory heats. Test results from small heats may therefore be accredited.

Chemical analysis of this 600-lb. mill heat was 0.065 C, 0.34 Mn, 0.28 Si, 2.91 Cr. 1.06 Mo, 0.14 Ti, 0.022 B. Titanium was 2.2 times the carbon. The Ti-to-C ratio is a matter of considerable importance and was given much attention in the Cornell investigation. At least 0.05% carbon is necessary to form austenite when soaking at hardening temperature and to harden the metal in subsequent cooling. Titanium's prime actions are to restrict the gamma field and to lock up carbon in a stable carbide. Therefore, if titanium is too high in relation to the carbon the steel is ferritic at all temperatures up to 2100° F. This effect is shown in Fig. 1, of three boron-treated steels each containing 0.08% C, but with varying titanium, all air cooled after heating in hydrogen at 2100° F. Note that the hardness decreases progressively as the titanium (and the Ti-to-C ratio) increases.

Extensive creep and stress-rupture tests reinforced the conclusion that when the titanium is somewhere between two and five times the carbon in these boron-treated steels, the steels are air hardenable, resist softening by tempering up to 1200° F. or more, and have superior creep and stress-rupture properties. Similar studies showed that boron content could vary from 0.010 to 0.10% without significant effect on high-temperature strength. This was surprising, because as boron increases beyond about 0.04%, an

Fig. 2 – Microstructures of 3% Cr, 1% Mo, 0.065% C, 0.14% Ti, Boron-Treated Steel After "Normalizing" (Soaking and Air Cooling) at 1700, 1900 and 2100° F. Nital etch, 500×

1700° F.; B-109 | 1900° F.; B-106 | 2100° F., B-107



unknown constituent appears at grain boundaries. The acicular ferrite matrix remained normal; expected hot shortness was not observed; likewise, the sheet had good ductility in reverse bending at room temperature. Evidently, then, the boron addition need not be regulated or limited with high accuracy.

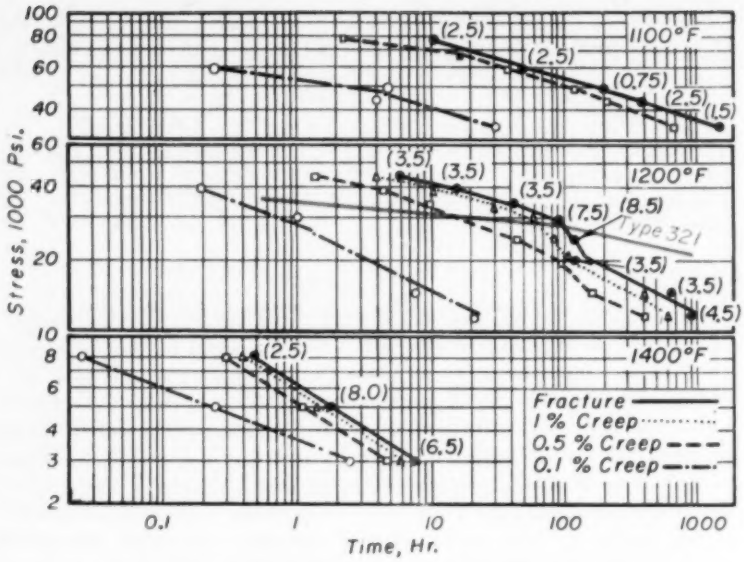


Fig. 3 – High-Temperature Creep and Rupture Properties of 3% Cr, 1% Mo, 0.065% C, 0.14% Ti, Boron-Treated Steel. 0.050-In. sheet samples tested after air cooling from 2100° F. Red line shows creep-rupture properties of Type 321 stainless (18-8 Cr-Ni, Ti-stabilized) at 1200° F.

Semicommercial Product

The composition for the 600-lb. heat was chosen after some 30 compositions varying in carbon, titanium, and boron had been melted in 30-lb. laboratory heats and their properties surveyed. The 3% Cr, 1% Mo basic analysis finally chosen approximates Comstock's steel No. 12, which was unbroken after 3300 hr. at 1100° F. and 30,000 psi., even though it had elongated 2%. The chromium is intended to increase oxidation resistance; the molybdenum to increase hardenability and especially to decrease "temperability" and creep at high temperature. Silicon at 0.28% represents the usual content for constructional alloy steels; the manganese of 0.34% retained from the melting stock is on the low side but is ample (with the titanium) to take care of incidental sulphur. Boron at 0.022 is a normal residual after boron treatment, and the combination of 0.065% carbon and 0.14% titanium (ratio 2.2) appeared about correct.

The metal possessed the metallurgical characteristics predicted by the preliminary work. A number of 1-in. square specimens of 0.050-in. sheet were quenched from various temperatures with the following results:

Quench	Hardness	Quench	Hardness
1300° F.	B-77	1575° F.	B-92
1350	B-78	1600	B-96
1400	B-77	1650	B-101
1450	B-71	1700	B-106
1500	B-68	1800	B-108
1550	B-78	1900	B-107

Full hardness is obtained in a quench from 1700° F. If the steel is soaked ("normalized") at higher temperatures there is doubtless a more complete solution of carbides (Ti, Cr, Mo or complex) but this does not show in the as-quenched hardness; the most evident change is austenitic grain growth and tendency toward a transformation product more acicular in nature. See Fig. 2.

A much more important point concerned with the relative strength of these fully hardened structures at 1100 to 1400° F., and a series of stress-rupture tests brought out the data shown in the following tabulation:

Stress-Rupture at 1100° F.

Time	N. at 1900	N. at 2100
10 hr.	65,000 psi.	80,000 psi.
100	45,000	55,000
200	30,000	44,000

Stress-Rupture at 1200° F.

Time	N. at 1700	N. at 1900	N. at 2100
10 hr.	23,000 psi.	31,500 psi.	38,000 psi.
100	14,000	20,000	27,000
400		12,000	15,000

Stress-Rupture at 1400° F.

Time	N. at 1900	N. at 2100
4 hr.	6500 spi.	8300 psi.
20	3400	4800

Thus the special steel sheet normalized (air cooled) from the highest temperature consistently has the best high-temperature strength at 1100 to 1400° F. Ductility (extension) at frac-

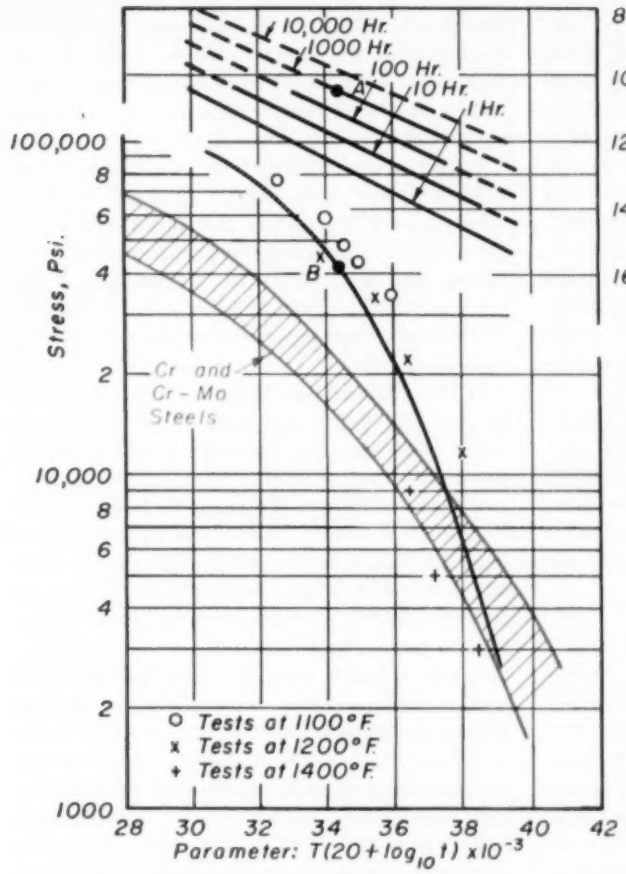


Fig. 4 — "Master Curve" for Boron-Treated Cr-Mo-Ti Steel, Drawn According to the Larson-Miller Scheme. In color is band for Cr-Mo steels up to 9% Cr, 1% Mo. The new steel is superior for combinations of shorter times and lower temperatures

ture was also higher for the samples heat treated at the higher temperatures. All this despite the coarsened grain shown in Fig. 2. The Cornell researchers conclude that strengthening from increased amount of foreign atoms dissolved in the ferrite more than compensates for the weakening effect of coarser grain.

To avoid decarburization, the samples were heated in hydrogen atmosphere. This high heat treatment at 2100° F. (which we can call Treatment A) would be a costly operation in commercial practice, so some 0.092-in. sheet was heated to 2100° F., air cooled to 1850° F. and then reduced to 0.075 in. in one pass, and tested in creep without further ado. This can be called Treatment B. (The previous stress-rupture results had been derived from 0.075-in. sheet rolled from 1850° F. max.) The stresses for 1% creep and for rupture in time periods varying from 10 to 200 hr. were found to be on the same order for both Treatments A and B, with Treatment B having a definite advantage as testing times increased. Treatment B gave better ductility because of the resulting smaller grain size.

It would appear from these results that final reduction in hot rolling should be performed after heating to 2100° F. If any fabrication operation must be done at lower temperatures — such as ceramic coating — the stock should first be preheated to 2100° F. and then cooled to the processing temperature if maximum hot strength is required in service.

A summary of the high-temperature tests of 0.050-in. sheet made from the 600-lb. heat and air cooled from 10 min. heating in hydrogen at 2100° F. is given in Fig. 3.

Percent elongation at fracture is shown in parentheses for the corresponding points. Plotted also in red on this graph is a line showing the average stress-rupture strength at 1200° F. for stainless Type 321 sheet (18-8 Cr-Ni, titanium stabilized) as given by A. I. Rush and J. W. Freeman in their "Statistical Evaluation of the Creep-Rupture Properties of Four Heat Resistant Alloys in Sheet Form", presented before the Chicago general meeting of the American Society for Testing Materials last June. It will be seen from this comparison that the low-alloy steel under study is definitely superior for lives at 1200° F. under 100 hr., but is definitely inferior for longer lives.

[Figure 4 is an attempt by *Metal Progress* to present stress-rupture data in Fig. 3 in the form of a Larson-Miller master curve* from the rather meager data of Fig. 3. This master curve enables reasonably accurate interpolation. For example, if stress for rupture time of 1000 hr. at 1050° F.

*See "A Time-Temperature Relationship for Rupture and Creep Stresses", by F. R. Larson and James Miller, *Transactions* of the American Society of Mechanical Engineers, July 1952, p. 765. In the horizontal parameter, T is °F. + 460, and t is the rupture time in hours.

were required, a vertical line from Point A on the upper diagram down to Point B on the master curve would indicate a stress of about 41,000 psi. on the left coordinates. For comparison, on this same figure is plotted in color a band within which fall the master curves of a family of chromium, chormium-molybdenum and molybdenum steels, ranging from 0.5 Cr, 0.5 Mo at the lower end to 9.0 Cr, 1.0 Mo at the upper.* It is apparent that the boron-treated Cr-Mo-Ti steel under study is considerably superior to the Cr-Mo steels at low parameters – principally lower temperatures – but no better at temperatures around 1400° F. Even at 1200° F. the creep-rupture strength drops sharply after 200 hr. or more, as shown in the center diagram of Fig. 3. These results suggest that the stiffening and strengthening effect of the supposed Ti-B-C precipitate tends to disappear with higher temperatures and longer times. Either the martensite tempers or the structure over-ages, depending on how you regard the mechanism.]

Welding

Some samples of 0.050-in. sheet, air cooled from 2100° F., were welded by the heliarc method with copper back-up strip to minimize the heat-affected zone. In one set the edges were flanged about 0.10 in. and the upstanding edges merely melted down. The bead or welt was then ground flush. Time at given stress for rupture at either 1100 or 1200° F. was cut to less than one-fifth of the values given in Fig. 3, and failure occurred at the edge of the weld metal, and this situation persisted even if the welded sample were heat treated.

Samples butt welded with filler rod of Type 347 stainless gave similar results – except under certain circumstances. If the bead was left on and the stresses low enough to give rupture times of 150 hr. or more, performance at 1200° F. approached that of the parent stock (Fig. 3).

Surface Protection and Carbon Content

A series of stress-rupture tests at 1200° F. was made of metal from the 600-lb. heat wherein the samples were given optimum heat treatments (in hydrogen). Results showed a downward trend of stress with decreasing thickness. This could be due to decarburization during rolling, heat treating and testing, or to oxidation of the metal during testing.

Evidently there is a composition and strength gradient from surface to center of these samples as is proven by the fact that when 0.064-in. sheet is surface ground on both sides to 0.050 in. and tested at 1200° F., it had strength significantly greater than the sheet rolled to 0.050 in. – in fact, was about equal to 0.081-in. sheet. These results indicated that surface scaling – at least up to 400 hr. – was not a factor.

Knoop microhardness tests across samples of 0.050-in. sheet and thicker showed hardness numbers of 375 at center and about 150 at surface – again indicating decarburization during rolling and hydrogen anneal, especially if the stock is slightly scaled. Thinner sheet (0.036 in.) was decarburized somewhat to the very center, Knoop hardness there being only 250.

It is recommended, therefore, that thin sheet be descaled before the final 2100° heat treatment. Otherwise, loss in carbon would lower the stress-rupture properties.

Decarburization is undesirable from another standpoint – namely, that even higher carbon than the 0.065% in the 600-lb. heat would have been desirable. This is indicated by a series of tests at 1200° F. on laboratory melts of boron-treated carbon-titanium steels, wherein the carbon and titanium were progressively increased, always staying within the ratio of 1.3 to 3.4. Figure 5 gives the results.

[While these steels contained no chromium and molybdenum and the stress of the 0.065% C steel at rupture in 100 hr. at 1200° F. is less than half that of the 600-lb. heat under study, the conclusion seems to be that commercial heats of the boron-treated Cr-Mo steel should contain up to 0.15% C and 0.40% Ti. It would be anticipated that the stress-rupture curves of such a steel would be materially above the curves shown in Fig. 3.]

Conclusions

"In the course of investigating the Ti-B type of ferritic steels for use as lean-alloy materials in high-temperature service, a number of generalizations have evolved which may be itemized as follows:

"1. Compositions of the 3% Cr, 1% Mo, Ti-B type have displayed high-temperature creep and rupture-strength properties in sheet form equivalent to the 18-8 Cr-Ni stainless steels at 1200° F. for times up to 1000 hr.

"2. These maximum strength properties are

*From "Report on the Elevated-Temperature Properties of Chromium-Molybdenum Steels", by W. F. Simmons and H. C. Cross, Special Technical Publication No. 151, American Society for Testing Materials.

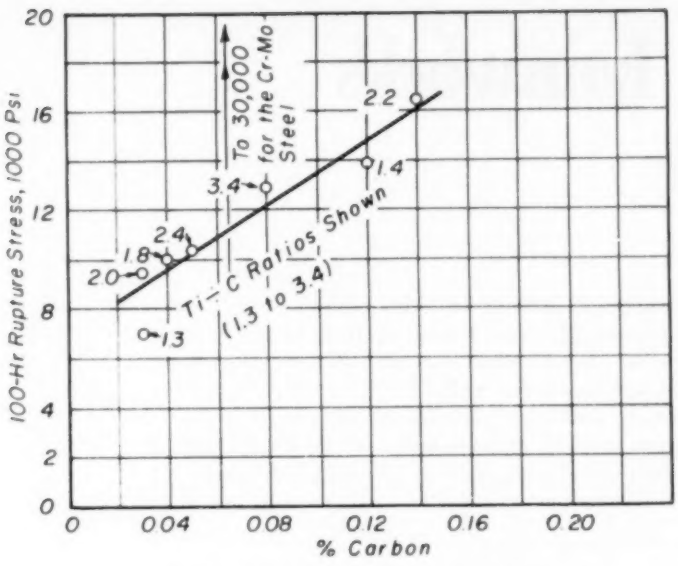


Fig. 5 — Higher Carbon Means Higher Rupture-Stress in 100 Hr. at 1200° F. — at Least in the Plain Carbon-Titanium Steels, Boron Treated

obtained with Ti-to-C ratio of 2 to 4. Some precautions must be taken to hot-work the alloy below 1850° F. to prevent defects resulting from hot shortness.

"3. It has been demonstrated that this steel ratio can be handled in a commercial mill; a 600-lb. heat was processed to sheet material.

"4. The high hot strength properties may be obtained in heats up to at least 600 lb. to the same extent as have previously been characteristic of 30-lb. laboratory melts.

"5. Heat treatment should be carried out in the range of 1900 to 2100° F. As the normalizing temperature increases, better high-temperature properties result because of the more complete solution of the titanium and boron, and of carbides of the alloying elements.

"6. Equivalent hot strength properties with higher ductility may be obtained from hot rolled sheet without subsequent normalizing. If rolling is done at 1850° F. the slab should be preheated to 2100° F. and then processed after cooling to the rolling temperature.

"7. While some decline in creep and rupture strength may be obtained in light-gage sheet, this can be avoided by protecting the surface from decarburization.

"8. High-temperature failure of heliarc welded joints occurs within the fusion zone both when no filler rod is used and when Type 347 stainless steel is used. Rupture strengths at 1200° F. equivalent to the parent metal were not achieved, although close approach was made with the Type 347 filler rod joint when the weld bead was not removed.

"9. The steel may be ceramic coated satisfactorily, yielding high-temperature strength properties characteristic of the finishing temperature used in the processing. Such coatings are of value in protecting against air oxidation at temperatures near 1400° F., although they are of doubtful utility at 1200° F., as shown by tests lasting several hundred hours.

"10. Increasing quantities of carbon and titanium with constant ratio Ti-to-C of 3 to 6 in the C-Ti-B steels and of 2 to 4 in the 3% Cr, 1% Mo, Ti-B grade improve the high-temperature properties up to carbon contents of 0.15 to 0.20%, the maximum quantities investigated.

"11. Boron, varying from 0.10 to 0.010% causes negligible change in the creep properties of C-Ti-B steels in spite of a eutectic network appearing in the higher boron steels.

"12. Molybdenum was very effective in improving the hot strength properties of the plain C-Ti-B steel; 1% Mo doubles the 1200° F. rupture strength for 100 hr.

"13. The phenomenal high-temperature strength of the Ti-B steels is related to their ability to form a hardened, low-temperature transformation product of acicular ferrite remarkably resistant to tempering. This is the result of solid solution hardening and diffusion interference effects of both boron and titanium, the retention of some carbon and titanium in the supersaturated ferrite, and the dispersion hardening effect of the precipitated titanium carbide."

Recommendations

"These favorable results warrant trial of this alloy in jet engines. While additional laboratory work may prove desirable, the most significant results can be obtained through service operation and testing. It is recommended that a 10-ton mill heat of 3% Cr, 1% Mo, Ti-B steel with 0.15% carbon, 0.45% Ti, and 0.010% boron be fabricated into sheet material for use in such jet engine parts as tail cones and combustion chambers."

The Saugus Ironworks

Where the steel industry of the New World took root 300 years ago

This rustic scene is an authentic restoration of the first successful ironworks built in this country in 1646 at Saugus, Mass., 10 miles north of Boston. The plant produced hammers, nails, axes, saws and other iron tools. The blast furnace (capacity 1 ton per day) is in the center, rolling and slitting mill at right, finery and forge just behind, and warehouse and wharf at left. (Courtesy American Iron and Steel Institute)

Induction Heating for Hot Forging

The Industrial Heating Equipment Assoc. sponsored three round-table discussions at the ⊕ Annual Convention in Chicago, early last month. The comments on heat treating occupied practically all of the November issue of *Metal Progress*. In the third meeting, devoted to induction heat, a group of three speakers described modern heating equipment for forge shops, and this matter will now be presented in somewhat abbreviated form.

Induction Heat

*By FRANK T. CHESNUT**

To start out, it would be well to answer the question, "What are the advantages of induction heat over a modern fuel-fired forging furnace?"

There is no cleaner or faster method to heat the usual run of pieces. Heating can be uniform — or patterned within wide limits. Energy is generated under the surface of the load and is not required to pass through a dirty or scaled exterior; color or condition of the surface has no effect on the heating rate.

Induction heating is very fast; little or no scale is formed, which means longer die life and less loss of metal; tolerances can be closer.

Induction heating can be almost completely automatic, requiring only unskilled labor. The equipment is cool to work around, so the operators greatly prefer it; there are no fumes, except those from oil on the dies or on the pieces to be heated, and there is no roaring noise of a flame. Since little energy is wasted, the over-all efficiency is high.

Finally, induction equipment as a whole is very compact and adaptable. The heater proper requires a minimum of space and can be located directly in a production line, immediately adjacent to the press it serves, or even as an integral part of the press.

Basic Equipment Requirements

Regardless of the frequency involved, the equipment comprises a power source, a heater unit or inductor, insulation, handling devices, and proper controls.

The power source may be an incoming power line, a motor-generator set, a spark-gap converter, or a vacuum-tube generator. Frequency can be anything from 60 cycles up to 500,000. As used in the business, the terms "low" and "high" frequency are relatively meaningless. "Low frequency" usually means that commonly supplied over commercial power lines (usually 60 cycles, although some 25-cycle power is furnished in some locations). "High frequency" is anything else.

The heating unit is in effect a simple transformer winding (or inductor) placed closely around or about the part to be heated. It is gen-

*Electrical Engineer, Ajax Electrothermic Corp., Trenton, N. J.

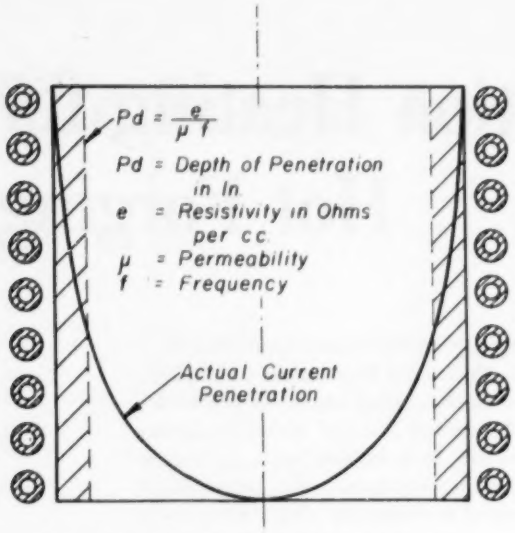


Fig. 1 – Calculated "Depth of Penetration" vs. Actual Current Penetration Plotted Against Section of Load Being Heated

erally made of copper tubing, water cooled to remove the heat generated by resistance offered to the passing current (I^2R losses, so called). Some heat is also picked up by radiation from the piece being heated, and this must also be carried away by the cooling water. Proper design minimizes the sum of such losses.

We will now consider the power source and heating unit in some detail.

Frequency and the Heating Cycle

Regardless of the frequency, the induced current in the piece being heated is distributed according to definite laws. True, the so-called "depth of penetration" is greater for low-frequency than for high-frequency current, but the greatest heating is always produced at or near the surface.

Figure 1 shows an induction furnace load in cross section, where the calculated "depth of penetration" is shown by the dotted line and actual current penetration by the solid line. Table I shows calculated depth of penetration

Table I – "Depth of Penetration" (Average in In.)

Material	Frequency (Cycles per Sec.)				
	60	1000	10,000	10^5	10^6
Steel (70° F.)	0.14	0.04	0.01	0.00	0.00
Steel (2200° F.)	2.6	0.64	0.20	0.06	0.02
Steel (melted)	3.6	0.89	0.28	0.09	0.03
Copper (70° F.)	0.34	0.08	0.03	0.01	0.00
Copper (melted)	1.2	0.29	0.09	0.03	0.01
Graphite (70° F.)	8.1	2.0	0.63	0.20	0.06

for various materials over a wide range of frequencies.* The important things to consider are that with induction the heating energy enters directly into the load, and is not affected by surface conditions; also that once generated in the piece, the energy flows by thermal conduction toward the center. To heat the entire piece therefore requires a definite time which cannot be shortened – except to a limited degree by increasing the rate and degree of surface heating or by using a lower-frequency current.

Frequency has relatively little effect on the time to heat a bar to the plastic range at the center; thermal conduction is the controlling factor. Economics perhaps plays a more important part; generally, the higher frequency costs more per kilowatt. As the bar diameter decreases, frequency should be high enough so that the electromagnetic energy is converted into heat in the outer surface layers rather than in toward the center of the load. Otherwise, you have a low power factor and low efficiency. As a very general rule it can be said that for the most efficient heating the diameter of the load should be six to eight times the figures in Table I.

Other items requiring consideration are the very great differences in flux penetration for magnetic versus nonmagnetic load pieces. Also the fact that for magnetic steel loads the depth of penetration is constantly increasing as the outer surfaces become heated above the Curie or magnetic point.

Heating time for any given production rate is also dependent upon the control and method of feeding. For example, the surface of the piece may be raised very quickly to the maximum safe limit of temperature (with high frequency even up to the melting point), thus assuring the fastest flow of heat toward the center. However, this can waste energy, and requires intricate power controls to prevent overheating at the surface. A better plan for individual loading is to strike an average heating rate with a constant voltage

*"Depth of penetration" of the induced current is an arbitrary term first derived by Steinmetz, then revised for induction heating by Northrup. It is the depth beneath the surface of an electrical conductor which defines an area that has a resistance to direct current equivalent to the resistance of the whole piece to alternating current at the frequency under consideration. About 75% of the induced current flows between the surface and the depth of penetration, and 87% of the induced energy is expended in this part of the charge. At twice this depth some 98% of the energy is expended, and at three times nearly 100%.

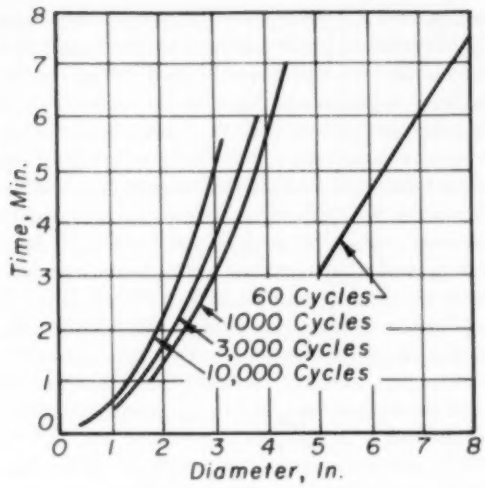


Fig. 2 – Approximate Time to Heat Various Diameter Steel Bars to 2100° F. With Difference of 150° F. Surface to Center. No soaking time included

supply, wherein the power may vary from beginning to end of the heating cycle but the piece becomes heated with sufficient uniformity for working. Parallel heaters loaded in sequence maintain a constant loading on the generators and a regular supply of heated pieces. Another good method is to pass the load pieces in succession through a series of coils so a cold one enters each time a hot piece is ejected; the load factor and the soaking time for temperature equalization can be good. Some equalization will also occur in the time lag between the heating and hot forming operations.

Figure 2 shows the approximate time to heat cylindrical steel bars to 2100° F., allowing a differential between surface and center of 150° F. (which must be equalized by a further soaking time).

The Heating Unit or Inductor

Inductors may be of a vast variety of sizes, shapes and types – single or polyphase, single or multilayered, series, or parallel connected, for unit or continuous feeding, and for a single or dual frequency operation. They may be of circular, elliptical, rectangular or other section and they may be hairpin, pancake, helical or beehive. In any event they should be adapted to meet a particular condition – and this is one of the prime virtues of induction heat. A primary rule is that the inductor embrace as much as possible of the area to be heated and that the coupling be close.

Commercial power lines usually are fed with balanced three-phase power. Hence, for low frequency, polyphase inductor systems have been general. High-frequency generators (and inductors), on the other hand, usually are single phase.

Single-phase inductors are simpler than polyphase, more adaptable and easier to combine for series operation without disadvantageous effects.

Multilayer inductors are inefficient except in a few low-frequency operations, the outer turns having a tendency to induce parasitic currents in the inner turns.

Inductors operating either in series or in parallel can insure a good load factor but if a series inductor fails the job is completely shut down. With parallel inductors production is only partially affected by failure of a single inductor.

Inductors may be adapted for unit operation, hand or machine fed, for heating a part in full, or on an end, or any other portion. Likewise they may be adapted for heating a succession of charges continuously.

The most common shape is the simple, single-layer helical inductor of circular or rectangular section, surrounding the load pieces. The coil may be horizontal, vertical or inclined. The load pieces may be fed lengthwise through an inductor of circular section or they may be fed sidewise through an inductor of rectangular section, or lengthwise into an eliptical inductor across the eliptical section and out at the far side. All of these methods are old and have been used repeatedly with good effect – so old, in fact, that no one company can claim "monopoly".

Hairpin inductors for heating the ends of elongated charges are quite common. Common, too, are variations where charges too large to be skidded through an inductor can be passed through the hairpin on bedded dollies.

Pancake inductors are not considered too effective. Beehive inductors can be energized and dropped over a load, either to heat it or to maintain temperature.

A vast number of yoke type inductors also have been used wherein the yoke concentrates flux into a specific part of a charge – as around the ends of a pipe to be upset or flanged. They are particularly well suited for lower frequency.

So-called "focus" inductors are also widely used for concentrating flux in a specific portion of a metal part.

Helical inductors are made in all sorts of configurations with turns spaced wider apart over areas where less heating of a load piece is desired or closer together where more heating is desired.

Poor coupling can also be used over sections where less heating is desired. Such coils may have enlarged or contracted sections to fit load pieces of irregular section. Finally, shunting capacitors or other arrangement can control the heating pattern in a load where the inductor is of fixed diameter or spacing.

Inductors are lined in various ways. Some, for lower temperature work, require only refractory or insulating tubes into which the load is fed or pushed. Some are provided with fitted bricks or insulating pieces butted together with refractory cement. Others have a tamped-in refractory lining formed around a mandrel, which is later removed. Still others are fully encased outside and inside. Vertical inductors require no more than a lining, but horizontal inductors usually are provided with water-cooled skids or rails on which the charge slides, insulated electrically from the inductor turns. (Being small in diameter, they pick up only a minimum of energy; the greatest heat loss to the skids is by contact with the load being heated.) In some instances slotted metal cylinders or sheaths, not water cooled, can be used for guides.

Controls

Controls can make or break any induction heating equipment. While there can always be an argument as to their number and nature, they are not only desirable but necessary. Induction heating equipment costs real money and is long lived. Seldom, if ever, is a job set up which outlasts the equipment. Of all the motor-generator equipment supplied since 1926, when they were first introduced, the author knows of very few which are not now in operation. Some of the melting equipments have been converted to forging equipments and vice versa. Some of the forging equipments – if not most of them – have been converted to different forging jobs, but by the initial and judicious selection of controls the greatest value of each installation has been maintained, and only the inexpensive inductors have been scrapped. While full control often is not required for a particular job initially, the author strongly recommends that it be included, feeling that its extra cost will be more than repaid in insuring long life and adaptability of the equipment.

The simplest control is an "off-on" switch between a constant voltage supply line and an inductor coil (manually fed). Usual controls, however, include a motor starter, exciter control, auto-transformer for load voltage control, load switch, protective interlocks, load feeding devices, and temperature measuring or actuated devices. The aim is to supply the greatest adaptability to the unit with the least number of operations to confuse an operator. Where a single operation is involved no problem arises. However, many equipments are permanently set up to handle a wide variety of load pieces and here pre-indexed set-up cards are provided for quick settings for any particular job. Some installations can handle as many as 100 press jobs with no more lost time in arranging new inductors than is required for changing the press dies.

60-Cycle Induction Heating for Forging

Low first cost of 60-cycle equipment makes induction heat competitive in bulk heating applications for forging and extrusion, where cost of high-frequency equipment has ruled it out of consideration.

HEATING by low frequency has long been known – in fact it has always been an unwanted effect in alternating current machinery. Electrical engineers have worked hard to minimize it.

It has also been used to advantage for over three decades. Recently I saw a 60-cycle heater which had been used for shrink-fitting for over 26 years. During World War II, 60-cycle heat did outstanding work in bomb nosing and in preheating tubes prior to forming. Its real growth was hindered by the fact that no one company had consistently developed the equipment. Even

now we recognize that 60-cycle induction heating is by no means a cure-all; it supplements high-frequency heating, monopolizing most induction jobs in the nonferrous field and taking over many larger heating applications for stainless and carbon steel and for titanium.

Basic components are similar to those for high-frequency heating (as outlined in the preceding paper by Mr. Chesnut), except that motor-generator or frequency-converter equipment is unnecessary. This saving in first cost is of prime importance when figuring the unit cost of heated extrusion billets or forging slugs in mass-production plants.

Heating coils are usually wound in a single layer. The one shown in Fig. 1 is a coil for single-phase, tapped at various places so surplus turns can be shunted when a short billet is being heated. A multi-layer coil cannot be readily tapped to reduce its effective length, although it may more efficiently use line voltage in a horizontal coil for continuous feed of metal, such as heating steel forging slugs.

Figure 2 illustrates a typical three-phase induction coil where each phase energizes appropriate sections along the length. Difficulty has been encountered, when the work was stationary, with cool regions at phase junctions, but this has now been entirely overcome by appropriate design. In fact, varying billet lengths may be used with a polyphase coil, and the section of the coil that covers a partial billet may be adjusted by changing the primary tap switch and adjusting the electrical input. This type of coil is a standard

and Extrusion

*By JOHN A. LOGAN**

in the aluminum and magnesium industry today. More than 100 such billet heaters, having an average rating of 350 kw. each, are serving aluminum extrusion presses.

The liner is responsible for nearly all the maintenance. When heating aluminum or magnesium (in the range of 1000° F.) or low-melting brasses (in the range of 1500° F.) split stainless steel liners backed with suitable thermal and electrical insulation generally last a year or more. Water-cooled stainless steel liners are necessary when heating cupronickels to 2000 or 2100° F.; guide bars, welded on, take the wear. These also last more than a year. Steel forgings require even higher temperatures, and coils are generally lined with a ceramic, cast or pre-formed, with water-cooled skid bars of stainless steel or Inconel. Their life is generally limited and repairs are frequent. Vertical coils, as shown in Fig. 1, avoid much of this maintenance.

Power Supply – Transformers usually have water-cooled secondary windings, with multiple taps. Line voltages frequently are as high as 5000 v.; secondary supply may range from 10 to 300 v., and up to 7000 amp. Induction heating inherently has a low power factor and, to correct this condition, shunt capacitors are connected across the primary of the transformer. This reduces the power drawn by the heater and limits the line current that has to be handled by the interrupting means.

Temperature control is the third major component. It can be done by a timer, a continuous feed device for a fixed rate, a contact thermocouple, or a radiation pyrometer. For accurate temperature control thermocouples are used for nonferrous work (Fig. 3), and radiation pyrometers for the high-temperature ferrous work.

For a steady flow of work, inexpensive timers or speed controls may be quite sufficient, especially if the line voltage is quite steady, and appropriate devices warn the operators of any sizable variation.

The Case for Low Frequency

The question is often asked, "What are the advantages of low-frequency induction heating over high-frequency?" The answer is that low-frequency equipment has a lower first cost. High-frequency generators vary in price from $60 to $100 per kw. This machinery is not needed in a low-frequency heater. One other great advantage is the increased penetration of current with the lower frequencies, resulting in more rapid heating on larger pieces. Needless to say, there is a specific place for both types of equipment and the user should carefully consider the advice of competent manufacturers before selecting the frequency for a particular operation.

It is true that for a specific size on a specific alloy, one certain frequency will generally have best electrical efficiency. This point must not stand alone. The difference in efficiency and the

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resultant power savings may not offset the difference in initial cost of equipment.

Aluminum and Magnesium

Line frequencies are not usually economical for aluminum and magnesium pieces smaller than 2 in. diameter, as is shown by the following approximate figures for the number of pounds of aluminum which can be heated 730° F. per kw-hr. (These figures are not exact, but are cited merely to indicate the trend.)

Diameter	Lb. per Kw-Hr.
2 in.	4
4	8
6	10
8	11
12	12
16	12

Even though it is obvious that the efficiency of heating, as measured above, drops off below 4 in. diameter, we have installed 50-kw. heaters alongside six toggle presses which are part of automatic feeding devices each handling 1100 pieces per hr. When the new installation replaced fuel furnaces, production rose from 750 to 1100 pieces per hr. (Increased production of only 50 pieces per hr. was sufficient to offset the increased cost of the heat.)

There is no maximum size limitation in the heating of aluminum or magnesium—in fact, the efficiency improves as the diameter increases up to approximately 12 in., where it tends to level off. The same figures are approximately true for magnesium. Good efficiencies are of much more importance when heating large-diameter billets than when heating small pieces. Total tonnage is relatively low even for a large production of small stuff, and the power cost represents a correspondingly small proportion of the total cost of production.

From representative installations for heating aluminum extrusion billets the following may be cited: One heats billets 8 in. diameter, 28 in. long, to 850° F. at the rate of 5000 lb. per hr.; it is rated at 625 kw., and operates from a 4160-v., three-phase, 60-cycle source.

Another installation is in an aircraft engine plant. Four heaters feed 8-in. diameter billets, 13 in. long, to two upsetters, a total of 8000 lb. per hr. The heaters operate on 440-v., three-phase, 60-cycle power. Capacitors are mounted on top the heater.

The largest 60-cycle heater known to the author handles 20-in. billets up to 65 in. long, and serves an 8000-ton extrusion press.

Several vertical heaters are under construction for the Air Force's heavy press program that will preheat aluminum ingots up to 32 in. in diameter and 70 in. long, weighing nearly three tons. They have one great advantage. This ingot is heated from room temperature to 850° F. in 30 min. The same ingot would remain in a fuel-fired furnace 14 hr. In other words, 28 times as much metal must be in process. The problems facing the operators in the event of an unscheduled shutdown would be much more serious if fuel-fired furnaces were used. Also the delay in getting a new load of ingots up to temperature can be extremely costly.

There are only a limited number of people extruding and forging magnesium. However, the largest magnesium extrusion plant in the world has five sets of induction heaters having a total capacity of approximately 3000 kw. Figure 4 shows the largest one. It heats in three stages at different rates in each, and allows for soaking in between for equalization. In this manner, a 15-in. ingot can be heated to extrusion temperature in about 8 min. Each heater is equipped with a temperature controller and prod-type thermocouple to measure the billet temperatures. All billets are taper heated; that is, the portion of the billet that enters the die first is hotter than that portion which enters last, which compensates for frictional build-up in the metal during the extrusion cycle.

Copper-Base Alloys

Handling of copper-base alloys differs little from the above. Low-frequency heating should be considered for stock 3 in. and longer. Billets of 10 to 12 in. diameter can be heated to 1600° F. at about 13 lb. per kw-hr.

Here, as in other installations where fuel-fired furnaces may be thought of first, floor space should be considered. A 2-coil heater, 700 kw. total rating, can heat 7500 lb. per hr. Floor space required is 50 sq. ft. A fuel-fired furnace would occupy 350 sq. ft.

Automatic handling and program control are additional features of these modern heaters.

Steel, Stainless and Titanium

As is true for the other metals, there are optimum limits in heating from the standpoint of efficiency and there are practical limits from the standpoint of the total cost. Forging of steel usually involves large tonnages, and large amounts of electrical energy are required. Quite often the frequency-conversion equipment even

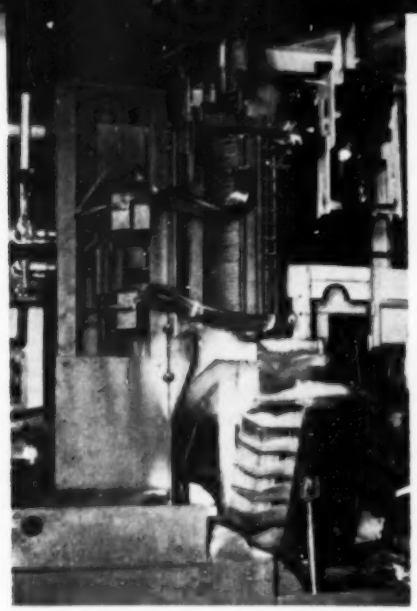
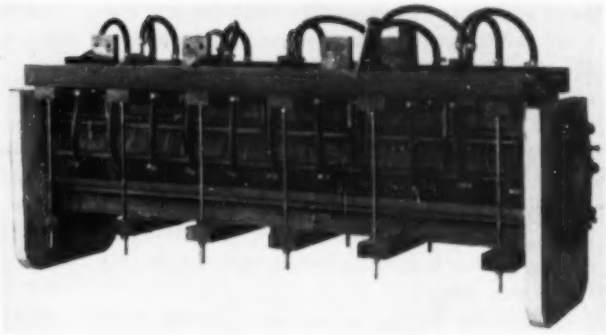


Fig. 1 – Vertical, Single-Phase Coil for 7 or 8-In. Steel Billets up to 28 In. Long, Tapped to Cut Out Turns for Short Lengths. Billet rolls into cradle, cradle tilts to vertical, and billet is raised by plunger into coil. Current is cut off automatically when Rayotube pyrometer registers current temperature. Construction gives minimum wear on ceramic liner of heating coil

Fig. 2 – Cover Removed to Show Three-Phase, 350-Kw. Coil for Heating of Aluminum Billets for Extrusion



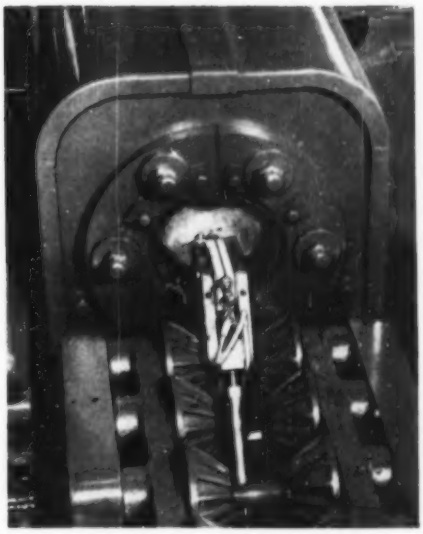


Fig. 3 – Thermocouple Built Into Billet Stop. Induced magnetic forces hold the billet against the stop and thermocouple prods pierce the billet skin, and operate the controls

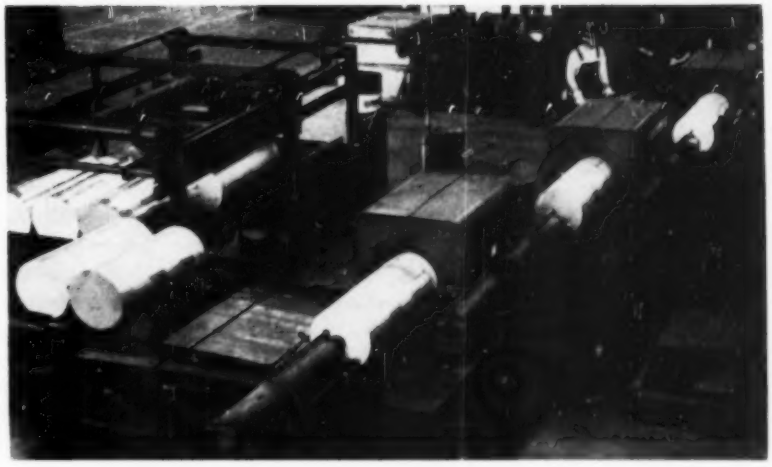


Fig. 4 – Triple Heater (One for Each Phase) Capable of Bringing a 15-In. Magnesium Billet to Extrusion Temperature in 8 Min. (at Rate of 6 Tons per Hr.) Each coil is rated at 500 kw. Heating is done in three stages; transfer is automatic

for the smaller sizes of bars is very costly and the metallurgist resorts to 60-cycle where induction heating has inherent advantages, even though high-frequency would be somewhat more efficient. Sixty-cycle installations are currently being made to heat 4-in., round-cornered squares up to 2300° F. Frequency converters are eliminated and the savings in first cost are believed to offset the slight reduction in electrical efficiency. When diameters are above 4 in.—certainly 5 in. or more—the decision about frequency, high versus low, must be weighed carefully, since the over-all efficiency of 60-cycle heating equals that of high-frequency equipment above this size.

Heaters for forging or extrusion presses must also be adaptable to intermittent operation and to variable billet lengths. Variable lengths (and sizes) can be handled in 60-cycle coils merely by changing the current taps without the necessity for a coil change, as shown in Fig. 1.

The thermal properties of titanium, together with its electrical properties, are in many respects similar to stainless steels, and the general heating practices are the same.

Summary

In summary, it may be said that line-frequency equipment in the aluminum industry is an established production tool. Over 100 such installations have been made since 1948. The brass industry has not been so rapid in expansion. Probably the greatest field for expansion is in the steel industry, particularly in those specific installations where induction heating has inherent advantages over fuel-fired equipment —namely the forging plants, the steel extrusion plants, and the high-alloy rolling mills.

The Case for High Frequency

*By FRANK T. CHESNUT**

Numerous examples from practice are cited to justify the author's thesis that high-frequency equipment (1000 cycles and up) can heat steel billets efficiently and rapidly, and that its adaptability is worth more than the extra cost of frequency changers.

THE FIRST article in this series presented a condensed summary of information about induction heat and heaters for forge shops, irrespective of the frequency of the current used. Mr. Logan then presented the case for 60-cycle equipment. I will now direct attention to the so-called high-frequency equipment, and finally Mr. Bernhardt will say something about dual-frequency.

It would be foolish to use high frequency if low frequency would do the work as well. If the heating or conversion efficiency in the inductor is about the same, why introduce all the extra loss, cost and liability for operation of a motor-generator set? But the conversion efficiency, on a comparable basis, is *not* the same. Furthermore, there are collateral advantages.

With high frequency the depth of penetration of the induced energy can be very shallow, insuring a maximum power input for a relatively small number of ampere turns. Fewer inductor turns and less current make for a more efficient and a very simple inductor – even more simple since most high-frequency power sources are single

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Table I—Selector Chart for Induction Heating for Forging or Upsetting

	Diameter of Stock	Power Lines *(a)*	Motor-Generators 10 to 1200 Kw. or More			Spark-Gap *(b)*		Vacuum Tubes *(c)*
		25 to 60 ∞	1000 ∞	3000 ∞	10,000 ∞	Hg-H 20 to 80 K ∞	Quenched 100 to 500 K ∞	150 to 540 K ∞
Ferrous	Up to ½ in.	—	—	—	C	B	A	A
	½ to 1 in.	—	—	C	A	A	A	A
	1 to 2 in.	—	—	A	A	B	B	B
	2 to 4 in.	—	A	A	B	C	—	—
	4 to 8 in.	B	A	B	—	—	—	—
	Over 8 in.	A	A	—	—	—	—	—
Nonferrous	Up to ¼ in.	—	—	—	B	—	A	A
	¼ to ½ in.	—	—	C	A	C	A	A
	½ to 1 in.	—	C	A	A	C	C	C
	1 to 2 in.	—	A	A	A	—	—	—
	2 to 4 in.	B	A	A	C	—	—	—
	Over 4 in.	A	A	B	—	—	—	—

(a) Not limited as to kilowatts *(b)* 2 to 40 kw. *(c)* 5 to 200 kw. (and even more)

phase. With a simple, single-phase inductor, a great deal more power can be crowded into a given space than with low-frequency or polyphase coils. Not only is heating more efficient, but end-effect, motor-effect and coil vibration are not major considerations.

The high-frequency installation is inherently of balanced loading and high power-factor. If the size of the installation justifies it, or if the over-all plant power-factor is low, a unity or even leading power-factor motor may be used. Fewer and cheaper capacitors are required to maintain a high-frequency load at unity than for the same load at low frequency.

Any well-designed high-frequency equipment can be used for almost any heating application as well as low-frequency equipment with very little change. It can also be converted for use in almost any other application such as melting, surface hardening or heat treating.

Low-frequency induction heating equipment has a very definite field, as Mr. Logan points out, but the equipment is limited to similar work. Some dual-frequency equipment is also justified when the cost differential between low frequency and high frequency is considerable. However, if either the abnormally high cost of high-frequency generators comes down, or if the size of generators is quite large, then the situation will need careful review. The cost per kilowatt will then be reduced and the motor-generator efficiency is increased. When this is added to the adaptability of the installation the net result may be in favor of a single high-frequency set rather than dual-frequency equipment.

The application chart, Table I, has been revised to conform with the best knowledge of the author at the present time. It shows where high frequency is now being used for hot forming, and many examples can be cited.* In Table I, A represents a common choice, B represents less frequent installations, and C rather rare choices.

Frequencies of the order of 450,000 cycles, derived from vacuum-tube generators, are very useful for heating small-diameter (up to ½ in. or so) charge pieces of either ferrous or nonferrous materials for forging or hot forming operations. Figure 1 is a chute-fed assembly for heating 9-in. lengths in the ½-in. stem of a previously upset stainless steel rod for a second forging operation. Powered at 50 kw., production is at the rate of one piece every 15 sec. or 240 pieces per hr. Another good example is a 200-kw. set supplying four sequence-timed heating stations. An automatic hopper feeds a piece to each station every 5 sec. Thus a 7-in. stainless rod, ⅜ in. diameter, is heated half-length to 1950° F., and delivered each 1.3 sec.

Figure 2 shows a typical equipment, motor-generator operated, for heating large bar stock for forging. Frequency for the unit shown would be 960, 3000 or even 10,000 cycles and power of the order of 100 to 200 kw. The heater proper can be placed on any side of the control equipment, and can be exchanged for other heaters if required. Somewhat simpler equipment would be used for an application where, once installed, it is not

*Editor's Note — Mr. Chesnut used 22 lantern slides to illustrate his thesis. There is room here for only a very few.

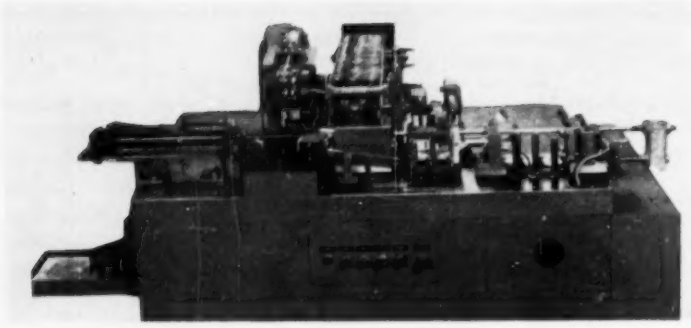


Fig. 1 – 50-Kw. Vacuum-Tube Equipment, Heating ¾-In. Stainless Steel Bars for Second Forging Operation. Production: 15 sec. per piece. Courtesy Induction Heating Corp.

likely to be changed. The heater would be "built in" and controls would be cut to a minimum. Equipment of this sort would heat a 16-in. length of a double-ended 2¾-in. diameter steel bar for a shell forging operation.

Large assemblages of such single-purpose equipment were made during World War II. Figure 3 shows one such, absorbing a total of 7000 kw. Each of ten 700-kw., 960-cycle generators operated a bank of seven heaters connected in parallel. Steel stock was 3 in. diameter by 18 in., and was heated to 2300° F. for forging 105-mm. shells. Heating time per bar was 4 min., which, sequence timed, provided one heated billet each 34 sec. per bank of seven heaters. The plant capacity was more than 25,000 shells a day. (Each of the ten equipments was converted postwar to other forging or melting operations.)

Figure 4 shows a typical inductor for round-cornered squares, about 1½ in. in dimension. Some heating equipment (3000 cycle) feeds such bars sideways, closely nested, through a flat, rectangular coil, but in this one the bars are fed through endwise. The coil is shown with its cover removed; it has a refractory inside lining and water and electrical connections for intermediate lengths of billet and power-control taps. Water-cooled skids support the load in its travel through the heater. This simple, rugged construction is typical of the single-phase inductors commonly used with high-frequency supply.

Note just behind the coil are rectangular covers over three other inductors. Similar chutes feed these coils also. Operations are timed in sequence; each bar remains in the heater 48 sec., and one hot one goes to the press each 12 sec.

A still different method of feeding consists of four in-line heaters, as operated by Ford's Canton Plant. Here billets 2½ in. diameter by 4 in. long are extruded into axle spindles. The assembly, powered at 700 kw. and 960 cycles, delivers one billet heated to 2250° F. to the press every 5 sec.—about 750 per hr.! A job similar to this one, figured in the early 1930's at dual-frequency, showed up as more costly over-all than the single high-frequency set-up here described.

Another interesting installation is in the forge shop of Cleveland Twist Drill Co. Strategically placed about the room are a dozen or more induction heating units, each feeding hot blanks to an individual forge. Most are heating rods from which drills are to be made, but others heat preforged blanks for the twisting operation. Two centrally located 150-kw., 10,000-cycle generators feed all of these heaters. The heaters in turn operate automatically as the steel blanks are fed into them. A 10,000-cycle frequency was selected because it could be used to heat the small diameters and would work almost equally well with the larger pieces. Drill blanks are heated so fast that the operator can hold the

Fig. 2 – Control Equipment and Heater, Fed by Motor-Generator Set, for Heating Steel Bars. Courtesy Ohio Crankshaft Co.

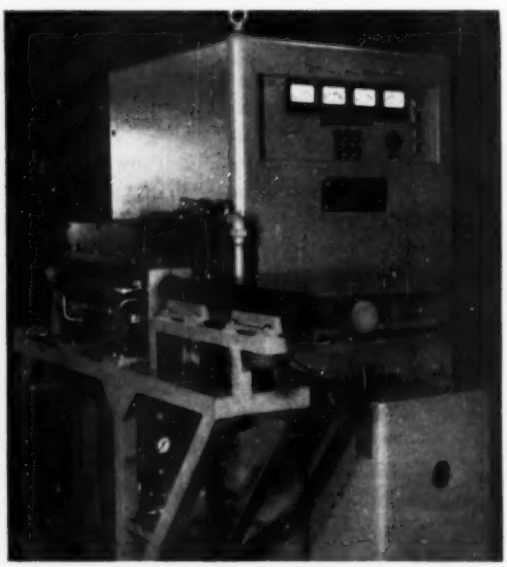
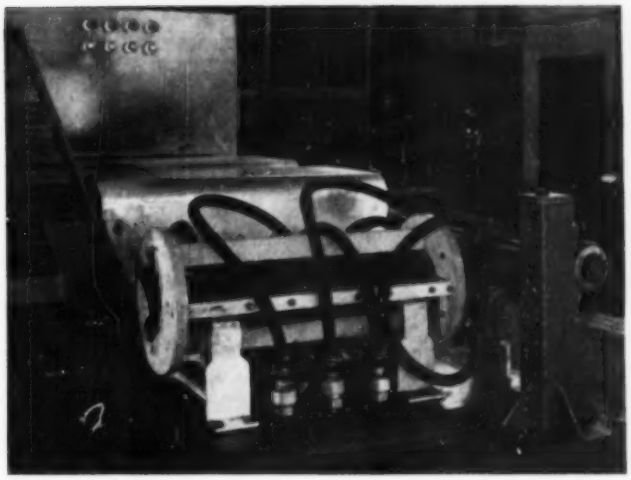


Fig. 4 – Typical Inductor Coil. Cover has been removed to show coil, power and water connections, and skids. Feeder is at left; exit rolls to right. Three other coils, under cover, are part of this four-unit set in a farm-implement plant



cold end in his gloved hand during the whole operation.

Finally, the notable plant of Massey-Harris Forge in Racine, Wis. can be cited for the great variety of work and simplicity of operation. Billets of a rather wide range in length and some range in diameter may be fed through the heaters, or an end or a selected mid-portion of a long bar may be heated. Where only a portion of a single piece is to be heated for hot forming or hardening, "pattern" heating is done. Over a hundred different jobs may be set up in the time it takes to change the press dies for each. Each separate job is card indexed as to tap connection, power and feed setting for maximum efficiency. Figure 5 shows a storage rack of the relatively low-cost heater units which on short notice can convert from one job to another.

This, then, is the case for the use of high-frequency induction heating for forging and hot forming. The field has only been scratched. There is much pay dirt below, as more and more forges turn to this new, clean and efficient method of heating.

Fig. 3 – Ajax Electrothermic Corp. Installation in World War II Shell Plant. All of the ten 700-kw. motor-generator units have since been converted to peacetime work

Fig. 5 – Heaters From 1-In. Rounds to 4-In. Squares, Each Card Indexed, Can Be Put in Production for a Hundred Jobs in Less Time Than It Takes to Change Dies

Dual-Frequency Heating for Hot Forging

*By CARL P. BERNHARDT**

**Should we use high, low or dual frequency?
The answer requires expert appraisal of many factors.
Mass production of fairly heavy steel items favors
low frequency for heating to the Curie point, and high frequency
for further heating to forging temperature.**

DUAL-FREQUENCY heating is the use, in combination, of two different frequencies to obtain the advantages normally inherent in induction heating.

Dual-frequency heating is not a new concept, although its wider use in production is quite recent. Let me repeat, briefly, some of the considerations already put forward by Mr. Chesnut in his first paper (p. 91).

As he pointed out, a magnetic field surrounding a conducting body concentrates itself toward the surface. The heat-producing eddy currents following the pattern of this magnetic field therefore will decrease rapidly with increasing depth.

A second important consideration, when heating iron and steel, is that a large decrease in permeability (on the order of 10 to 1 or more) occurs at the Curie point, about 1400° F. Above the Curie point, the magnetic field penetrates much deeper with a consequent increased depth of current penetration. As a result, the heated depth is greater. This change in average depth of current penetration† at the power densities generally encountered in forging practice is shown in the table below:

FREQUENCY IN CYCLES	DEPTH OF CURRENT PENETRATION†	
	BELOW CURIE	ABOVE CURIE
60	0.500 in.	2.60 in.
960	0.120	0.65
3,000	0.060	0.39
10,000	0.030	0.20
450,000	0.005	0.03

For best heating efficiencies, as a very general rule, the diameter of the load should be six to eight times the figures in the above table. Satisfactory efficiencies can usually be obtained with diameters half as large. In some applications somewhat smaller ratios of diameter may be used at 60 cycles, where the user is willing to accept increased power cost in order to obtain less expensive equipment. Such applications must be carefully considered from the standpoint of over-all economics.

On the basis of a diameter 3½ times the depth of current penetration, the following table shows the relation between diameter of workpiece and current frequency for heating of a typical steel for forging. These figures are for diameters of rounds or for equivalent cross-sectional area of round-cornered squares.

DIAMETER	FREQUENCY IN CYCLES	
	BELOW CURIE	ABOVE CURIE
¼ to ½ in.	3000	450,000
½ to 1	960	10,000
1 to 1½	960	3000 to 10,000
1½ to 2	60	3000
2 to 6	60	960
6 and over	60	60

While 60-cycle frequency is indicated for large billets (6 in. and over), the over-all economies of equipment cost and operating efficiency favor dual-frequency heating for smaller sizes. However, for bars smaller than 1½ in., dual frequencies will not ordinarily be justified economically; it will be better to supply the total power from a single high-frequency source, at the frequency required for the "above Curie" condition.

There are no hard and fast rules which will

*Manager, Industrial Section, Sales Department, Westinghouse Electric Corp., Baltimore, Md.

†Approximately 87% of the total heating effect occurs in a ring around the periphery, equal in thickness to "depth of current penetration".

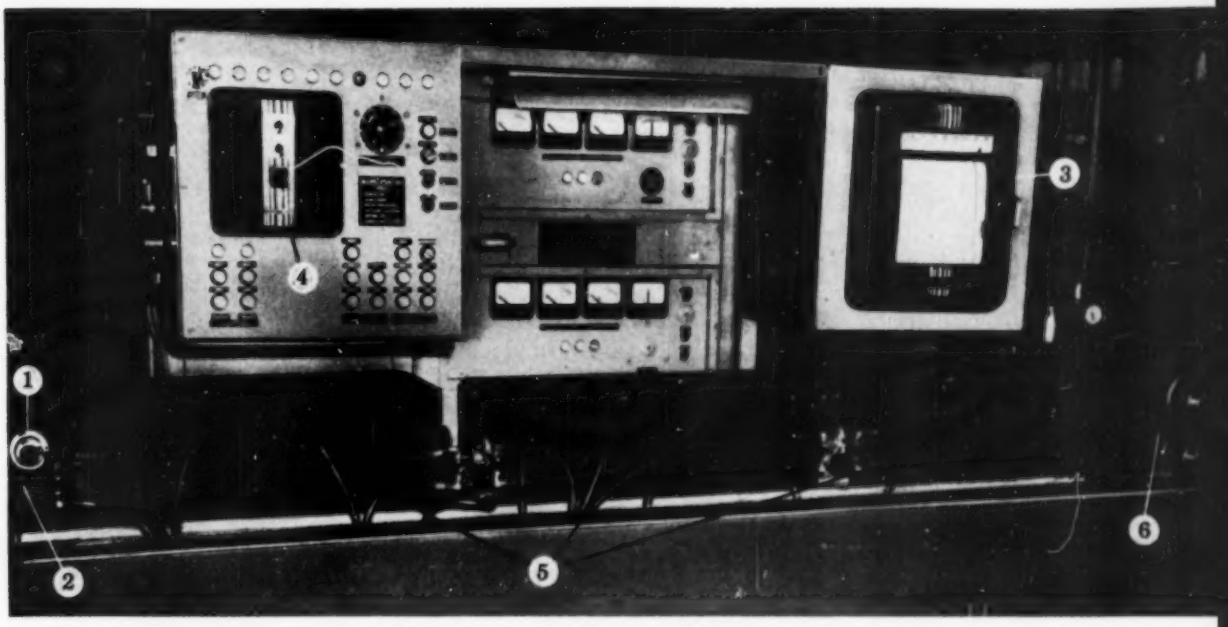


Fig. 1 – Dual-Frequency Coils for Heating Small Rounds for a Nut-Forming Machine (not Shown, at Left). Courtesy Ohio Crankshaft Co.

define the range of sizes best handled with a given frequency or combination of frequencies. Much will depend upon the process requirements, *range* of sizes of pieces to be handled in the given equipment, space available for the heating coil or line, operting power costs, plant power factor correction required, and the specific job requirements.

All of these factors can be evaluated by competent manufacturers working in close cooperation with the users.

In applying dual-frequency heating, the general rule is to provide equal heating time for the 60-cycle and high-frequency stages; the power inputs are about equal.

The heating time necessary for reasonable temperature equalization is approximately proportional to the square of the diameter of the billet, being in the order of 6 to 8 min. for a 4-in. round-cornered square. To obtain a final differential temperature not exceeding, for example, 50° F. center to surface, a soaking time can be provided at the exit if handling time to press is short.

Some Representative Applications

Even though this paper is to describe the through heating of steel for forging, it can be mentioned at the outset that the concepts of dual frequency heating are not new, and their use is not confined to hot forging applications. For example, dual frequencies are successfully used to harden transmission and large bull gears. At one place machines contour-harden transmission gear teeth at a rate of 900 gears per hr.; the gears are on a conveyer and are indexed successively through three preheating coils at 10,000 cycles, and for 0.6 sec. in a 200-kw., 200,000-cycle coil, then water quenched. Here dual frequencies made a continuous process line possible, with results which could not be obtained with a single frequency.

The first example of forge heating (Fig. 1) concerns stock too small for line frequency – a completely automatic heater and feeder for a press that makes 4200 nut blanks per hr.

Steel bar up to 1¼ in. in diameter, stored in a 4-hr. storage rack, is fed to chain-driven feed rollers. These feed the stock (6) through the three inductor coils (5). As the hot bar emerges, it moves into a cut-off and nut-forming machine. The formed nuts drop into an oil quench, and are later picked up by a steel conveyer. Scale loss has been reduced to only about 1% for hot rolled stock.

The first two coils, operating from a 300-kw., 3000-cycle, motor-generator set, preheat the rod. The third coil, operating from a 250-kw., 10,000-cycle, motor-generator set, brings the rod to forging temperature, 2350° F., plus or minus 25°,

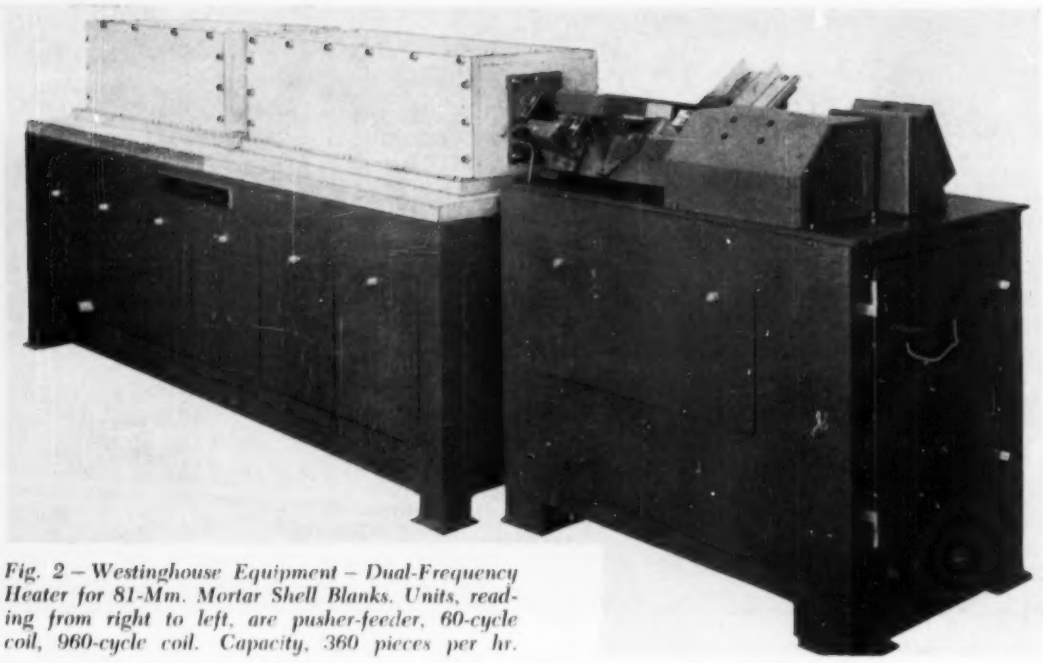


Fig. 2 – Westinghouse Equipment – Dual-Frequency Heater for 81-Mm. Mortar Shell Blanks. Units, reading from right to left, are pusher-feeder, 60-cycle coil, 960-cycle coil. Capacity, 360 pieces per hr.

with very high efficiency at the high end of the temperature range. The generator instrumentation and control are located on the center panel. Automatic control and recording of temperature is by a Rayotube (1), and the equipment on the other two panels (3) and (4). These control the excitation of the motor-generator sets.

The second example concerns the heating of considerably larger pieces – shell blanks 2½ in. diameter by 3¾ in. long, weighing 5.3 lb. each. Four units such as shown in Fig. 2, set in parallel, feed two presses making 81-mm. mortar shells. Each unit discharges one billet every 10 sec. at 2250° F., with a surface-to-center differential of about 50°. Rated production of the four heaters (two presses) is therefore 1440 shells per hr.

The entire equipment operates from a 440-volt, 3-phase, 60-cycle power supply, and comprises:

Four induction heaters, like Fig. 2, with mechanical billet handling equipment, two arranged side-by-side as a dual unit.

Four 175-kw., 960-cycle motor-generator sets, with controls.

Four 60-cycle power-factor correction capacitor racks.

Four 60-cycle control cubicles.

The induction heater shown in Fig. 2 contains a magazine-loading chute for the billets, which drop singly through a releasing mechanism synchronized with a horizontal pneumatic pusher. The billets are thus progressively fed through the 60-cycle inductor coil section, the 960-cycle inductor coil section, and discharged to a trough, which holds the billet for removal by the operator to the press immediately adjacent.

The multiple layer, 60-cycle coils are single phase, built up in four sections, each separated for ready removal, and are water cooled. A wear plate is provided within the split stainless steel liner. The single-layer, 960-cycle water-cooled coil is in multiple section, has a ceramic type liner, and water-cooled guide rails. The power is approximately evenly divided between the 60-cycle and 960-cycle sections.

The capacitors for the 960-cycle section are located within the base, which also contains the necessary control for the feed mechanism. Billets can be fed rapidly through the machine to clear it when desired. The control system also protects the equipment in the event of a jam or absence of billets.

The third example which is now going into service is the largest installation of continuous-feed dual-frequency forging heater thus far made. Six billet heating machines, shown in Fig. 3, heat 40 tons of steel per hr. to forging temperature, to produce 105-mm. shells. The 3.5-in. round-cornered square billets, 8 in. long, are heated to 2150° F. at a rate of 480 per hr. in each heater.

This heater is a dual line, in which duplicate sets of two 60-cycle coils for below Curie, and two 960-cycle coils for above Curie, heat two separate rows of billets as they are pushed through the coils. The heater is 25 ft. long and 5 ft. wide.

The coils are water cooled; the water discharges through sight drains into a common trough at the side. The power factor correction capacitors for the 960-cycle operation and the feeding controls are located in the base of the machine (doors removed for photography). Figure 3, of the discharge end, shows two of the "Radiomatic" radiation pyrometers to measure final billet temperature, and to operate mechanical devices for bypassing underheated billets separately through a trap door into an inclined chute. A hydraulic mechanism also orients the billets being discharged from the soak chamber to the single-file take-away conveyer, for delivery to the press.

At the entrance is a power-driven roller conveyer, which delivers the billets in single file to a double-acting mechanical shuttle, which alternately indexes a billet in front of the pusher for the right or left line of heating coils. The feed rate is controlled by a cam timer, electrically interlocked with the press cycle.

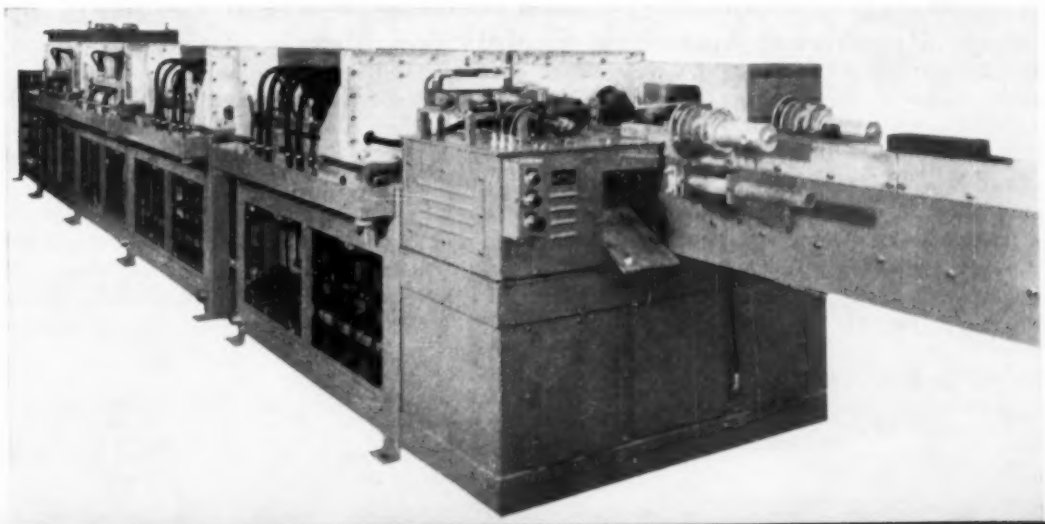
The operator's control desk contains two indicators and recorders for temperature of each billet as it is discharged, generator voltage control, 60-cycle and 960-cycle instrumentation, and pushbutton controls.

Power input to the billet heater, to meet the press production rate, is controlled by pre-set of the voltage-regulated 960-cycle motor-generator.

The entire equipment operates from a 6900-volt, 3-phase, 60-cycle power supply, and comprises six induction heaters, like Fig. 3; six 1000-kw., 960-cycle motor-generator sets, with controls; six 1800-kva., 60-cycle capacitor racks to correct line power factor to 90%; six 1500-kva., 60-cycle power centers, with three-to-two phase transformers for 480-volt inductor coil operation; and six control desks with separate temperature indicators and recorders for each billet line.

Heating in process is often required as the part is put through subsequent forming operations. In such applications it may be desirable to utilize 60 cycles for the initial mass heating because of its lower investment costs, and utilize higher motor-generator set frequencies for the more limited zone heating necessary in the later stages of production.

Fig. 3 – Discharge End of Very Large Dual-Frequency Heater for 105-Mm. Shell Billets. Units, reading from right to left, are outfeed mechanism, two 960-cycle coils, two 60-cycle coils. Feed mechanism is at far end, not shown. Capacity 480 pieces, or 6.7 tons per hr. Courtesy Westinghouse Electric Corp.



Summary

The trend is toward the increasing use of induction heating for hot forging. Dual-frequency heating will assume an important role in forging, because it is a method to obtain substantial economies in first costs, and in operating costs.

Dual-frequency heating has the advantages inherent in induction heating, which are:

1. Rapidity of heating. This means a very low scale loss (less loss of metal) and longer die life.
2. Automation can be realized to a high degree.
3. In-line production, since heater can be adjacent to the press.
4. Working conditions are greatly improved, due to absence of noise, radiated heat, and fumes.
5. Short start-up time.
6. Stand-by losses are low or non-existent.
7. Accurate repetitive control of temperature means consistent uniformity of heated billets, less flash, and a saving of metal.

George A. Roberts

Vice-President—Technology
Vanadium-Alloys Steel Co.

President, American Society for Metals, 1954-55

With the exception of the two summers from school during which he worked for RKO Pictures and Bell Telephone Laboratories, George A. Roberts has been with Vanadium-Alloys Steel Co., first as research metallurgist, then chief metallurgist, and from 1953 as vice-president of technology. The scope of his interests and work during these years is revealed by more than 20 papers on subjects ranging from inhomogeneity in austenite and its effect on hardenability, to the metallurgy of toolsteels and of prealloyed steel powders. A large measure of the credit belongs to him for the science of preparing these steel powders now being made by Vanadium-Alloys and the development of the high-vanadium high-carbon toolsteel (known in the trade as Super Hi Speed).

He has participated in numerous ⊕ activities, being past chairman of the Pittsburgh Chapter, member of the national Publications Committee, member of the Board of Trustees, and has just completed a term as vice-president, becoming the Society's 1954-1955 president.

George Adam Roberts was born Feb. 18, 1919, in Uniontown, Pa., but spent his boyhood in Pt. Marion, Pa., where his father was school superintendent and his mother organ and piano instructor. As best as he can recall, his boyhood and early youth were uneventful, even to the extent of missing by a distance of one mile from becoming a southerner. He enrolled in the Naval Academy at Annapolis at the age of 16, the youngest not only in his class but in the Navy at that time. It was on account of this distinction that he appeared as a speaker during an anniversary commemorating the Academy's 90th year. After the usual number of speeches had been made by the usual assemblage of dignitaries found at such functions, the program acquired a symbolic note with the appearances of the oldest admiral and the youngest midshipman in the service. George Roberts left the Navy two years later because his vision dropped below the acceptable standard.

If George had not chosen Carnegie Institute of Technology to complete his education, he would very likely have become the mathematician he intended to be rather than the metallurgical engineer he was persuaded to become. Robert F. Mehl ⊕, head of the metallurgical department, interviewed George at the time of his admission to college and convinced him of the opportunities available in metallurgy. He graduated in 1939 and received his doctorate in science in 1942.

Dr. Mehl's teachings had a profound effect on George Roberts. Mehl was an exacting pedagogue but a stimulating one; he demanded a scientific attitude in a field that was still being taught and learned at many places in a manner similar to that being used with nonengineering subjects; he demanded attention to detail but did not lose sight of the broader aspects of each problem and of its relationship to others; he demanded thorough understanding of underlying principles and constant reference to them in the analysis of all problems.

George met Betty Mathewson under scholarly auspices — in a German grammar class. They married and he continued with the final year of his studies.

The Roberts family numbers two boys, 12 and 10 years old, and a girl 5 years old. George has devoted himself to their interests in many ways, at home with their hobbies (the younger boy has organized a science club and has an attic lab), on short trips and excursions to places of interest to his children, by starting Cub Scouting in his church and by organizing and managing a Little League baseball team.

Civic responsibilities have also received his active support, his most recent duties being chairman of the Latrobe Community Chest campaign and president of his city's zoning commission. For relaxation he plays the piano (he is also an accomplished clarinetist and saxophonist, but the music made by these is less sociable, he believes) or putters in his woodworking shop.

In a period when individual success is too often advertised as an accomplishment won by ability alone, it is refreshing to talk to a man who attributes much of his success to good fortune. George admits that ability is essential, but strongly disputes that it alone is important.

Because he had spoken of qualifications in individuals, it seemed appropriate to ask him for the qualifications he sought in those coming to him for jobs in his department. His preference is for a man having a strong background in engineering fundamentals. Five years of engineering schooling would be an ideal qualification, but the duration of study is not as important as thoroughness. He believes that some knowledge of the "humanities" and of the world we live in is essential to an engineer, but he questions the value of a smattering of education in subjects such as accounting, business administration, economics and finance. The student-engineer receives such an infinitely small exposure to them that the likelihood of ever using this

knowledge in his early career is very slim. Later, when the engineer must make decisions at the policy level, he has the services of specialists in those fields to prepare the business briefs on which he can base his decisions. Also, the engineer can get such practical knowledge as he may need from individuals in those fields.

Inasmuch as George has a knack of expressing uncomplicated opinions, I asked him what he thought of the statement made by an executive that excessive amounts of money are being spent on appurtenances to research rather than on research itself. George conceded that this is a way to spend money on research, but he did not believe there were many foolish businessmen. George thinks that if any criticism can be made of the research conducted over the past dozen years or so (during which the word "research" has acquired an aura of importance, not only in industry but even to the man in the street), it is that there has been too much burning of joss sticks to "paying" research and not enough attention to "fundamental" research. This trend is spreading to the universities, and although not many are now guilty of devoting too much attention to this kind of research, they are in danger of doing so. He believes that engineering research is best handled if left to industry, and conversely, fundamental research is primarily the concern of universities.

J. PARINA, JR.

Corrosion Resistance of Carbo-Nitrided Steel

*By P. A. CLARKIN and M. B. BEVER**

"Compound layer" in carbo-nitrided cases reduces the corrosion rate in tepid salt solution to half that of carbo-nitrided steel without the layer and that of carburized steel, variously heat treated. Compound layer proved undesirable in sea-water exposure long enough to penetrate the case.

THIS REPORT summarizes an exploratory investigation, in which the corrosion resistance of a carbo-nitrided steel was determined in two mediums; carburized specimens were also tested as a standard of comparison. This work was undertaken because increased corrosion resistance is among the advantages claimed for the carbo-nitriding process of case hardening steel, but no experimental data supporting this claim appear to have been published.

Test pieces of normalized A.I.S.I. 1018 were surface ground and case hardened at temperatures ranging from 1400 to 1700° F. in various atmospheres which contained 3 to 5% methane (or natural gas) and 0 to 15% ammonia, the balance being carrier gas. Some specimens were case hardened in a laboratory furnace and others in production equipment. All specimens were oil quenched and some were tempered.

Carbo-nitriding at low temperatures and with high ammonia concentrations results in the formation of a layer of carbon-nitrogen-iron compounds at the surface of the steel. (See Bever and Floe's Chapter 7, Case Hardening of Steel by Carbo-Nitridng and Cyaniding, in "Surface Protection Against Wear and Corrosion", ASM, Cleveland, 1954.) The compound layer resembles in some respects the white layer formed in nitriding, and this resemblance may have contributed to the belief that the corrosion behavior of carbo-nitrided steels is similar to that of nitrided steels.

Our corrosion tests were carried out by total

*Mr. Clarkin is research assistant and Dr. Bever is associate professor, department of metallurgy, Massachusetts Institute of Technology, Cambridge.

immersion in an aqueous solution of 3% sodium chloride and in fresh, flowing sea water. Eight liters of the former were used in a jar maintained automatically at 30.0 ± 0.5° C. The solution was aerated with 400 ml. of air per min. per liter. Four specimens, each having a surface area of approximately 0.12 sq.dm., were immersed simultaneously for two to four days. In the sea-water tests, three series of specimens, each having a surface area of about 0.3 sq.dm., were exposed for periods of 21 to 133 days to sea water moving at a speed of 1 to 2 ft. per sec.

Salt Solution – In the sodium chloride solution all carbo-nitrided specimens *without* any compound layer at the surface corroded at essentially equal rates, regardless of the conditions in the heat treating furnace, which had been varied over wide limits. Also, the corrosion rates of these specimens were of the same order as those of the carburized specimens. Tempering also had no appreciable effect on the corrosion behavior of carburized and carbo-nitrided specimens in the salt solution. The average rate of weight loss for all of these specimens was 180.1 ± 6.9 mdd. (milligrams per square decimeter per day). Attack was essentially uniform; no pitting was observed. Some specimens had dark surfaces after carbo-nitriding in the laboratory furnace, probably due to reactions occurring during the quench. When this thin dark layer was romoved from half of a set of duplicates, the corrosion rates in the sodium chloride solution were essentially equal for both conditions.

The carbo-nitrided specimens *with* a compound layer at the surface corroded in the sodium chloride solution at approximately 94 mdd. This is about half the rate of the specimens discussed above, and indicates a marked superiority of this type of carbo-nitrided case in sodium chloride solution.

Sea-water immersion was so long that the cases of many specimens were completely corroded away. The measured values of corrosion, therefore, do not refer to the case alone. No definite correlation between the rate of corrosion and the case hardening treatment is possible. It is significant, however, that in sea water a heavy calcareous deposit formed on carbo-nitrided specimens having a compound layer at the surface. This deposit is attributed to the fact that the surface is cathodic to the underlying metal, and it may be concluded that once such a case is penetrated, corrosion is accelerated by galvanic action between the core and remaining case. Cases *without* a compound layer, on the other hand, had only traces of a calcareous deposit or none at all. Figure 1 shows three specimens at the upper left which had a compound layer and were severely pitted, while a more uniform type of attack occurred on the other specimens.

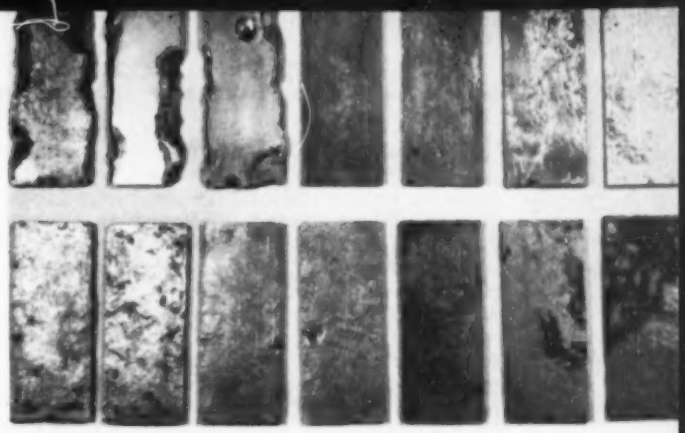


Fig. 1 – Specimens of Case Hardened Carbon Steel After 4½ Months' Exposure to Fresh, Flowing Sea Water. Specimens were cleaned before photographing. The three specimens at the upper left were carbo-nitrided under conditions leading to the formation of a compound layer. The other specimens represent various other conditions of carbo-nitriding and carburizing. The third and fourth specimens in the bottom row are untreated steel

In summary, this investigation has shown that, after carbo-nitriding under conditions which do not lead to compound formation, plain carbon steel corrodes in aqueous sodium chloride solution at the same rate as after carburizing. Wide variations in the carbo-nitriding conditions and tempering have no appreciable effect on the corrosion behavior in this solution, but the presence of a compound layer at the surface markedly improves its resistance. The sea-water tests, which were carried to the point of complete penetration of the case in some specimens, suggested that under such extreme conditions the compound layer may be undesirable.

For applications which require a case possessing both moderate hardness and moderate resistance to corrosion in mediums such as sodium chloride solution, however, carbo-nitriding under conditions which produce a compound layer at the surface should be considered.

Acknowledgments – Support of this work by the ammonia division of Armour & Co., Chicago, is gratefully acknowledged. Thanks are due to Ipsenlab of Rockford, Ill., for case hardening some specimens. The writers are especially indebted to the corrosion engineering section of the International Nickel Co. for conducting the tests in sea water at the Marine Test Station at Kure Beach, N.C.

Atomic Energy Act of 1954*

[The Atomic Energy Act of 1946, frequently referred to as "The McMahon Act", is a 12,500-word law which transferred the property and activities formerly supervised by Manhattan Engineer District of the U.S. Army to the direction of a civilian commission of five members. Early this year, President Eisenhower asked the Congress to amend this law in several respects, principally to widen the areas of permissible cooperation with foreign nations and with American private enterprise, and to modify previous cumbersome security practices (see *Metal Progress* for April 1954, p. 101). The Joint Committee on Atomic Energy held two extended series of hearings on these matters†, an amended law was written and passed. This 20,000-word document is the "Atomic Energy Act of 1954". Following are extracts — by permission — from an extensive analysis of this new act, published by the National Assoc. of Manufacturers, wherein the words in quotation marks are from the act itself, and wherein attention is restricted to important changes in the old law.]

Industrial Participation — Except for the use of radio-isotopes, private industry has hitherto participated in the atomic energy program only as a contractor for the government. Ownership of all facilities for the production of atomic fuels rested in the Atomic Energy Commission. The present statute provides that individuals or firms may now be licensed to build and operate such facilities for use in medical therapy [and the provisions for this are especially liberal] and for industrial research.

The law also permits private ownership of reactors or facilities for the production and utilization of special nuclear material‡ but only under license. While all material capable of inducing a nuclear chain reaction is the property of the government, the Atomic Energy Commission may lease a sufficient amount of special nuclear material for the authorized purposes for a reasonable charge.

As a prerequisite to the above arrangements, the Commission must find that the facility "has been sufficiently developed to be of practical value for industrial or commercial purposes". Licensees must comply with safety standards, agree not to construct an atomic weapon, and furnish the Commission such technical information derived from its operations as the Commission decides is necessary for national security and public health. Licenses are non-exclusive, non-transferable, not to exceed 40 years, and the facilities may be repossessed by the Commission in the event of war or a national emergency declared by Congress.

Since special nuclear material may be generated in privately owned reactors, provision is made for the government to buy it at a price fixed in "consideration of the value of the special nuclear material for its intended use by the United States, and the actual cost of producing that material".

Inventions — All new inventions in the atomic energy field are patentable (except those solely useful in an atomic weapon, and compensation will be tendered for them). Inventions made under "any contract with the Commission" become the property of the government; the inventor may, however, appeal to a Board of Patent Interferences. No patent may be issued on any inventions already known or used, even though "such prior knowledge or use was under secrecy within the atomic energy program".

After finding any privately owned patent to be of primary importance (1) in the production or use of special nuclear material or atomic energy, or (2) in effectuating the policies and purposes of the Atomic Energy Act, the Commission may use such patent and grant use of it to other persons engaged in authorized activities; the royalty fee shall be fixed by a Patent Compensation Board.

Security — As in the Act of 1946, the Commission must control the dissemination of information and the classification of restricted data, "so as to provide that free interchange of ideas and criticism which is essential to scientific and industrial progress and public understanding and to enlarge the fund of technical information". It is now further directed to "maintain a continuous review of restricted data and of any classification guides" so as to declassify what can be published "without undue risk to the common defense and security". [Therefore the Commission now has greater freedom in releasing engineering information of importance to American industry, and information about the utilization of atomic energy.]

The statute requires an investigation by the Federal Bureau of Investigation or the Civil Service Commission of all persons having access to restricted data. [This changes the old requirement for a uniform investigation of all persons employed by the A.E.C. or its contractors, no matter how lowly their jobs.] Certain persons may be designated by the President or the Atomic Energy Commission to have a high degree of importance or sensitivity; the F.B.I. is required to investigate such persons. Thus the nature of the investigation is related to the extent and sensitivity of the information to which the person has access.

International Relations — The Act authorizes (under stipulated safeguards) bilateral cooperation with foreign nations in the area of peacetime uses of atomic energy, including the transfer of information and atomic materials suitable for non-military and research purposes. "The President is authorized to enter into an international arrangement with a group of nations providing for cooperation in the non-military applications of atomic erengy" [subject to certain requirements designed to minimize the chance of misuse of the information and fissionable material which will be pooled].

The President may also authorize the Department of Defense to communicate to mutual defense organizations information necessary to train personnel in the use of atomic weapons and the defenses against them.

*Complete text can be found in House of Representatives' Report No. 2666, Aug. 16, 1954.

†Transcripts are printed in "Atomic Power Development and Private Enterprise" (1st Session, 83d Congress) and "Hearings on S. 3323 and H.R. 8862, Parts I and II" (2nd Session, 83d Congress).

‡"Special nuclear material" in the Act is defined to include plutonium, "uranium enriched in the isotope 233 or in the isotope 235", and materials for the fusion as well as the fission process.

Book Review...

Physical Metallurgy Reviewed

*By CHARLES S. BARRETT**

PROGRESS IN METAL PHYSICS, Bruce Chalmers, Editor. Vol. 1, 401 pages, 1949; Vol. 2, 213 pages, 1950; Vol. 3, 334 pages, 1952; Vol. 4, 403 pages, 1953; Vol. 5, 318 pages, 1954; Interscience Publishers, Inc., New York City. First four volumes, $8.00 each; Vol. 5, $9.50.

THESE DAYS a man who is trying to keep up with the technical literature has rough going. Each research laboratory keeps turning out reports as if its life were at stake (and not infrequently it is!). Journals enlarge their issues. Methods and theories continually increase in number and become more elaborate, and the world's stock of experimental data grows at an accelerating rate.

This situation has brought about an increased need for summaries of the literature. A man finds that he needs reviews of what is new, both in his own field and in various related ones. In recent years this has been shown by the attendance at seminars, and the sales of books based on them, as well as the sales of other "review" type of books. The reader wants them to be authoritative and well written, illustrated, referenced, and indexed, and he likes wide coverage. If he is a metallurgist, for example, he also wants to know something of the new methods, data, and theories of the physicists.

The now-famous series of books entitled "Progress in Metal Physics" has done a great deal to meet exactly these needs. The plan is to have one volume appear each year, reviewing a few subjects in physical metallurgy and metal physics in considerable detail. The editor chooses the subjects and the chapter authors, and thereafter leaves the treatment largely up to the authors. Obviously the choice of subjects is important. They must be live matters of current interest, subjects in which significant advances are being made, perhaps subjects about which controversy has heightened the interest.

Choice of authors is no less important. What good is it if a well-chosen subject is attacked by a man who understands it poorly, or lacks the judgment and writing ability to organize his understanding into a form that benefits others? Under such circumstances the value of the review is no greater than a well-bound list of references and is inferior to a good set of abstracts. It is not easy to find authors of this caliber. [Amen!]

A great factor in the success of the series is the service of Bruce Chalmers as editor. He is excellently equipped to select subjects and authors and to set the tone of the books. He has himself written books, summaries, and papers of the highest merit in both pure and applied science. He has wide first-hand knowledge of metal physics, and, as editor of *Acta Metallurgica*, is in a position to judge of current interests and the relative capabilities of authors around the world. His standing in research and in literature is such that he is able to attract, persuade or intimidate these men – however he does it – into writing.

A word of credit should go to the man who picked Chalmers for the job and gave him the finances and freedom to carry out the work. This was P. Rosbaud, a man of long experience in scientific publishing, known and liked by countless technical men here and abroad.

The books are not intended as textbooks, since the individual chapters are written more or less independently, and the treatments do not always go back to elementary principles. Nevertheless, they could be of service in advanced courses in physical metallurgy where previous acquaintance with fundamentals can be assumed. In this use they would be in competition with some very fine monographs written by some of the same authors (for example, Cottrell's "Dislocations and Plastic Flow in Crystals", and Hume-Rothery and

*Dr. Barrett joined the Institute for the Study of Metals at the University of Chicago in its first year (1946) after having been on the Carnegie Institute of Technology's faculty for 14 years. He is author of "The Structure of Metals", acknowledged the standard work in that field.

Raynor's newly revised "Structure of Metals and Alloys"). They would also compete with the ASM Seminar series on some subjects. This reviewer's opinion is that most of the chapters measure up to this competition in satisfactory fashion. They are well written, well illustrated, and always accompanied by excellent lists of references.

Since the books can be purchased individually and vary in interest, there is room only for detailed comment on the last two volumes. The list of contents of the others can be had for a postcard to the publisher. The plan of the series fortunately provides for reappraisal of topics as necessary, and a good treatment of "crystal boundaries" in Vol. 1 is brought up to date by Editor Chalmers in Vol. 3. Dislocation and diffusion theories are also treated again in later volumes with references back to statements in Vol. 1. The second volume is smaller. Its main feature is a group of articles on the changes in structure that take place during annealing – particularly the rearrangement of dislocations that constitutes polygonization.

Volume 3 treats, among other things, of the crystallography of transformations in metals and alloys. The 72-page chapter on recrystallization and grain growth is particularly timely. These always-important subjects have been advanced in recent years by recognition of some important mechanisms that are treated in detail.

Volume 4 brings two earlier chapters up to date – namely, those on diffusion and dislocation theory. In the diffusion chapter le Claire emphasizes the need for considering skeptically most of the early chemical diffusion data and shows what kinds of data have the most meaning. Cottrell, in his chapter on dislocations, points out that the dislocation theory is becoming steadily more successful in predicting effects quantitatively that can be tested experimentally, and is laying the ground work for an understanding of work hardening, a problem still too complex, however, to be more than partially understood at this time. Another metallurgist, G. A. Geach, discusses recent theories of sintering. One is impressed with the fact that different experiments on sintering indicate different mechanisms, which presumably means, as Geach points out, that the nature of the material and the existing stress conditions may determine which of several mechanisms are important in a given experiment.

Although there is little chemistry in the series, Vol. 4 includes a physical chemist's view of recent ideas on oxidation mechanisms and rates, as given by Karl Hauffe, one of the most active German investigators in the field of surface reactions.

The most recently published volume (Vol. V) includes Ronald King of the Royal Institution in London as co-editor with Bruce Chalmers. The leading article is a "Report on Precipitation" by H. K. Hardy and T. J. Heal – a monograph in itself of 135 pages and 350 references. Much space is given to the transition states in age hardening alloys that are revealed by the newer X-ray techniques. Various structural studies of individual alloy systems are critically discussed, as well as the relations of structural changes to property changes during aging. The authors point out numerous specific alloy systems for which their appraisal suggests that current knowledge is incomplete or current ideas are of doubtful worth.

N. J. Petch has written a praiseworthy digest of some 180 references on fracture up to 1952, in which he contrasts the principles for brittle substances with those for ductile metals; he covers both the theoretical side of the subject and many aspects of the practical side. It is refreshing and stimulating reading, for most of his conclusions are clear and positive. Students of brittle fracture may differ with him on some points but will certainly approve of his treatment on the whole.

In a chapter on liquid metals and alloys, B. R. T. Frost gives a comprehensive review of the X-ray determinations of structure together with shorter discussions of other less direct determinations based on thermodynamic measurements and changes of physical properties on melting. Theories of melting are treated briefly, but this portion has less to recommend it, for considerable attention is given to theories that are now considered to be over-simple or incorrect. An expert in statistical mechanics may say – pounding his fist on the table, very likely – that you cannot possibly explain melting as a sudden change in the properties of one phase. The change of properties of both individual phases is gradual, and melting occurs at the temperature where the two phases have equal free energies. Frost concludes with the statement that there is *no* satisfactory theory of melting. Experimental facts regarding solidification of metals in the form of columnar grains, dendrites, single crystals, and crystals with pronounced substructures are discussed in a chapter by Ursala Martius. This includes studies by Chalmers and his co-workers at Toronto, Pfann's purification of metals by zone melting, and some of the basic principles involved.

To the numerous readers of "Progress in Metal Physics" it is good news that the publishers plan to continue the series indefinitely.

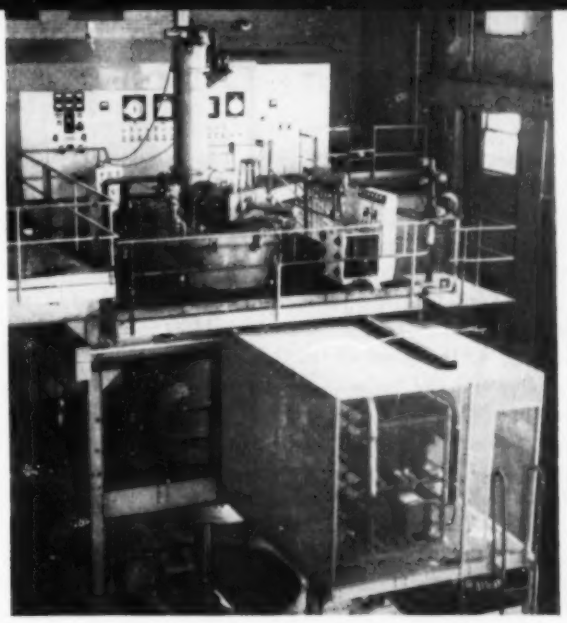


Fig. 1 – Vacuum Melting Furnace Which Makes Six Half-Ton Heats in a Single Rundown. Courtesy Universal-Cyclops Steel Corp.

Vacuum Melting– Commercial and Experimental

By Our Own Correspondent

Electrochemical Society discusses various types of commercial furnaces for reactive metals like titanium, molybdenum and zirconium, to say nothing of furnaces for high-temperature alloys and specialty steels melting three tons per rundown, where improved properties are worth the extra cost.

THE ELECTROCHEMICAL SOCIETY at its 106th meeting in Boston early in October sponsored, for the first time, a symposium on vacuum processing. This was both appropriate and timely in view of the rapidly growing interest in the general field, and particularly in vacuum melting by the makers of specialty metals. In fact, it was of wider interest than the planning committee realized, and the meetings had to be moved at the outset to larger quarters in order to accommodate about 250 engineers and scientists, many of whom had a direct interest in the subject.

J. M. Blocher of Battelle Memorial Institute, chairman of the symposium, arranged for 20 papers on various subjects which publicized for the first time much good work which has been going on during the past several years.

The symposium was introduced by J. D. Nisbet of the Universal-Cyclops Steel Corp., who pointed out that modern technology demands that vacuum processing be put on a commercial scale in order to control imperfections in metals. The range of purities that can be achieved by various melting practices was outlined and estimated roughly as follows:

Electric furnace	0.1%
	(one part per thousand)
Vacuum induction furnace	0.01%
Vacuum arc furnace	0.001%
Levitation melting	0.0001%
Zone melting	0.00001%
	(one part per ten million)

Levitation melting, by the way, is now under study in the Westinghouse Laboratory. Molten metal is suspended in a magnetic field in a

vacuum system, and therefore has no contact with containers or reactive elements of any kind. Zone melting is becoming a commercial process for purifying germanium and silicon for electronic applications.

Universal-Cyclops' vacuum furnace (described in "Critical Points" for October, p. 113) is shown in Fig. 1. It makes six 1000-lb. heats in 18 hr., whereupon the vacuum is broken. By extrapolating vacuum melting furnace sizes, both arc and induction types, Nisbet suggested that the next significant step in furnace building should be on the order of 10,000-lb. capacities.

P. C. Rossin of General Electric Research Laboratory described for the first time some of the fundamental phenomena in electric arc vacuum melting at various pressures and pointed out the prospects this process has for controlling the purity of metals. He also emphasized the desirable features of eliminating ceramic containers for molten metals. Howard R. Spendelow, Jr., I. S. Servi and Glenn Fritzlen suggested that the composition of induction vacuum melted alloys could be controlled fairly close to the range of analytical accuracy.

Robert G. Ulrech of the Consolidated Vacuum Corp. reviewed the applications of vacuum technology to metallurgical processes and outlined the distinctive features of modern induction furnace designs.

There were several papers which described various types of furnaces for vacuum melting. It is clear that this process is going through a transition from a laboratory curiosity to pilot-plant production. G. J. Crites of the F. J. Stokes Machine Co. presented a paper on economics. His analysis, which he admitted was a paper analysis of the problem, indicated that vacuum melting would not cost a great deal more than air induction melting. Based on the assumptions made, which some commentators thought very conservative and others very liberal, he concluded that material might be vacuum melted for 13¢ per lb. in 1000-lb. furnaces.

There were several other papers on the properties of vacuum melted alloys. W. F. Moore and R. K. McKechnie of the General Electric Research Laboratory described deoxidation practices on a specific complex high-temperature alloy. Another contribution by R. L. Hadley and L. M. Bianchi, also of General Electric, published for the first time practical information on the oxygen content of various alloys as related to the melting and hydrogen deoxidation practices.

E. R. Morgan and Donald Frey of the Ford Motor Co. described the outstanding corrosion resistance at 2300° F. of a 15% Al-Fe alloy, vacuum melted. It is superior in oxidation resistance to stainless steel; however, the evil of brittleness at low temperatures has not yet been solved. The authors think this is not inherent with ferrite; perhaps it is associated with impurities. If these can be brought under sufficient control by elimination or ineffective distribution, a wide variety of applications seems assured for this alloy.

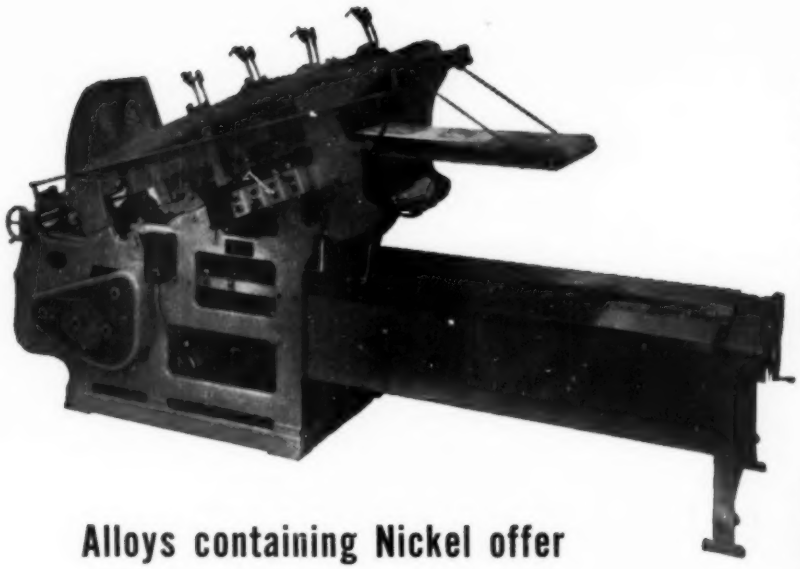
Richard L. Hoff and A. M. Bounds of the Superior Tube Co. described vacuum heat treating techniques and presented a convincing case for their commercial use. The heat treatment of metals in vacuo on a commercial scale without unreasonable cost would seem to be a nearby development.

Vacuum degassing of titanium was described by C. B. Griffith and M. W. Mallett of Battelle Memorial Institute. Since the properties of this metal and its commercial alloys are seriously impaired by a few hundred parts per million of hydrogen, some method of degassing will undoubtedly be rapidly expanded to match the growing titanium industry.

Earl A. Gulbransen of the Westinghouse Research Laboratory gave a scientific paper on a new method for the evaluation of high-vacuum furnaces and heat treating atmospheres. He suggested that even very high vacuums achieved only in small laboratory apparatus oxidized the surface of metals enough to be detected with the electron microscope.

There were several papers on vacuum pumping equipment. C. M. Van Atta and R. L. Sylvester described a new mechanical pump that could achieve a blank-off pressure of 10^{-4} mm. Hg. Such a pump should have wide applications in clean systems. It was pointed out in the discussion that this might be difficult to maintain in commercial melting systems that inherently carry through a considerable amount of metal particles. Efficient traps or filtering systems are also necessary.

It was apparent from the corridor conversations that vacuum processing is receiving a great deal of devoted and enthusiastic attention on the part of scientists and engineers. Great strides have been made in recent years in getting this process out of the laboratory and into production pilot plants; moreover, it appears that the process will develop at an even greater pace in the next months. Perhaps at the next vacuum symposium, the tonnage steel industry will participate.



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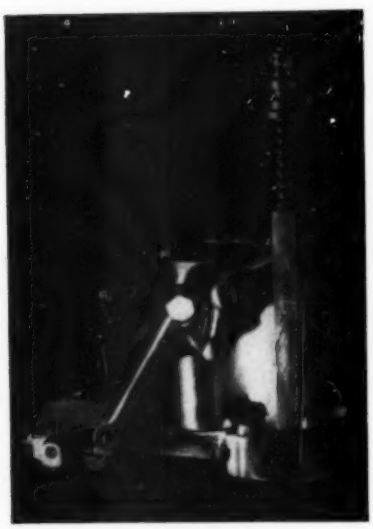

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Air-Corrosion of Fe-Ni-Cr Alloys

(which also contain about 0.4% C, 1.2% Si, 0.8% Mn)

By ANTON deS. BRASUNAS

Metallurgy Division
University of Tennessee, Knoxville

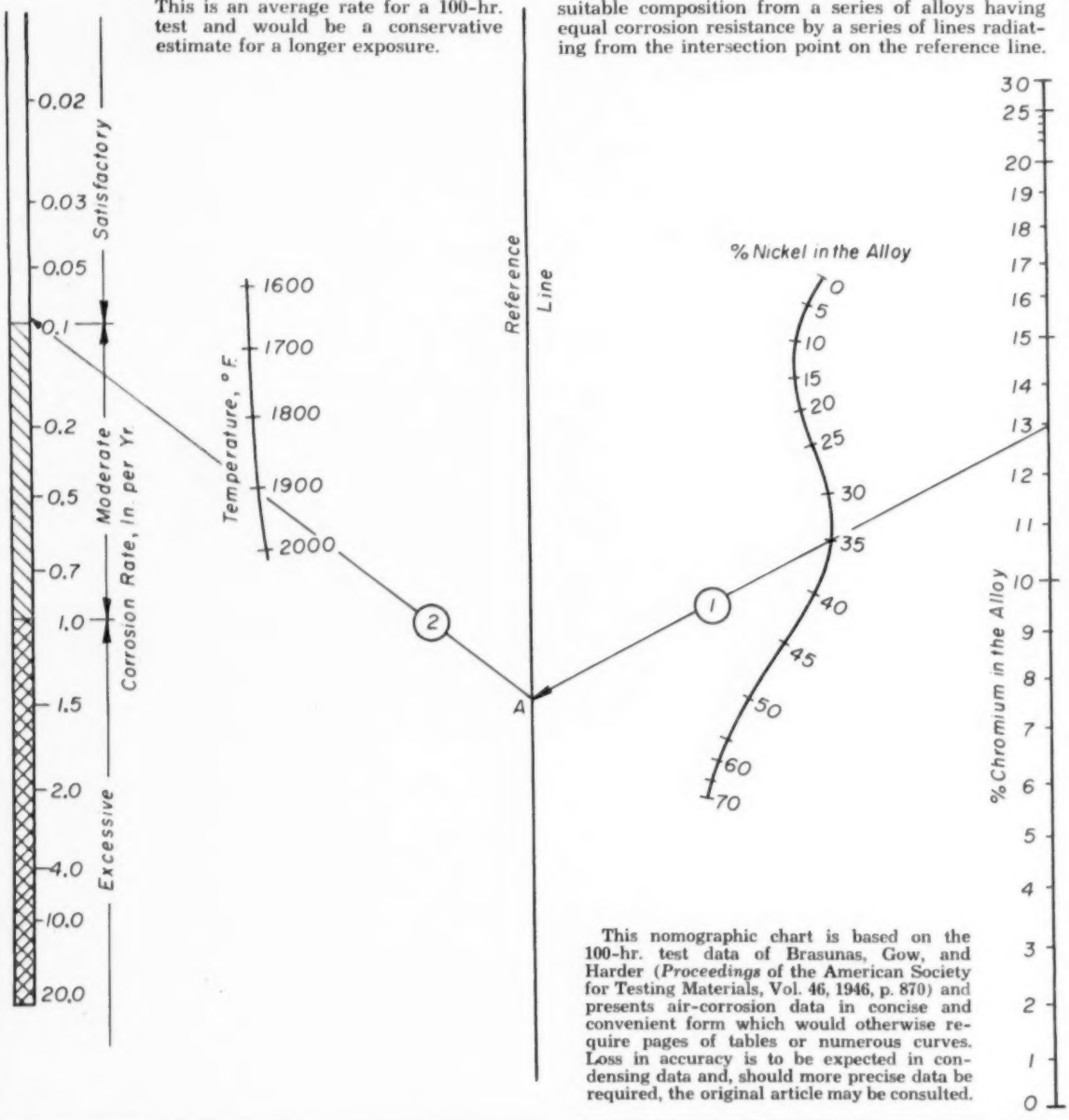
To Use the Nomograph

KNOWING THE COMPOSITION AND TEMPERATURE

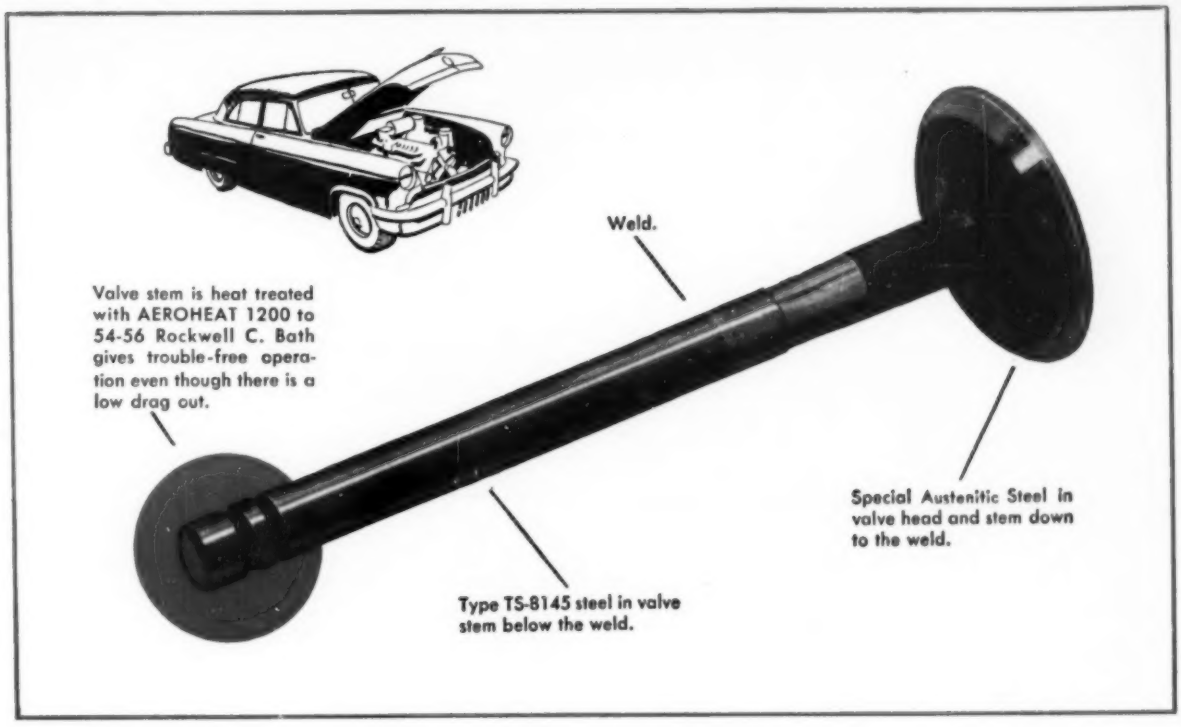
If an alloy of 13% Cr and 35% Ni were contemplated for use in air at 1900° F., estimate the corrosion rate as follows: Draw a straight line (1) connecting the % Ni and % Cr to intersect reference line (A). Then draw another line (2) through the temperature selected—1900—and read the corrosion rate—in this case, about 0.09 in. per yr. This is an average rate for a 100-hr. test and would be a conservative estimate for a longer exposure.

KNOWING THE TEMPERATURE AND TOLERABLE CORROSION

By reversing the above sequence one may select a suitable composition from a series of alloys having equal corrosion resistance by a series of lines radiating from the intersection point on the reference line.



This nomographic chart is based on the 100-hr. test data of Brasunas, Gow, and Harder (*Proceedings* of the American Society for Testing Materials, Vol. 46, 1946, p. 870) and presents air-corrosion data in concise and convenient form which would otherwise require pages of tables or numerous curves. Loss in accuracy is to be expected in condensing data and, should more precise data be required, the original article may be consulted.



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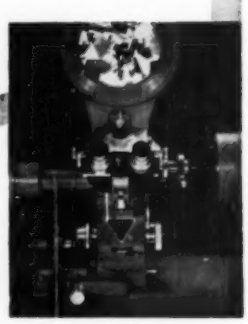

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Metallurgical Equipment

Grinding Cemented Carbides

*A Review by ARTHUR H. ALLEN**

New grinding processes – electro-discharge, electrolytic, ultrasonic, and silicon carbide belt and wheel grinding – circumvent the need for diamond wheels in tool dressing. Improvements in diamond grinding and efficient salvage of waste materials also help conserve the dwindling supply of bort.

PRACTICAL applications of new processes for machining and grinding cemented carbide tools are being accelerated in the interest of conserving a faltering supply of crushing bort and diamond powder. Current expenditures by industry for research and development in this field are approximately $2 million annually, with government agencies providing additional assistance. Particularly in the past two years has the pace of this activity quickened, following an exhaustive report (MAB-18-M) by the Minerals and Metals Advisory Board of the National Research Council. This study evaluated new processes for machining and grinding operations where diamond bort was being used, and made recommendations to further advance these processes. While only limited distribution of the text was made, it was reviewed at length in the technical press (*Metal Progress*, August 1952, p. 87).

Since then techniques have advanced so rapidly that a supplementary study seemed advisable, so a small task group of the panel assigned to the subject carried out further investigations†, leading to six new general recommendations (MAB-54-C). These point up the need for *(a)* industry's continued responsibility for research and development; *(b)* government participation in such work; *(c)* the desirability of continuing and extending industry's use of new machines; *(d)* a mechanism for periodic studying and reporting; *(e)* continued educational programs; and *(f)* consideration of collective action by industry to supplement and improve field test development work.

Diamond bort consumption has been mounting sharply in recent years, principally because of the vast expansion in the industrial use of cemented carbides for tools and dies. For exam-

*Technical-Business Consultant, Cleveland.

†Most of the data on which this report is based were derived from interviews by the Task Group with representatives of Behr-Manning Co., Buick Division of General Motors Corp., Carboloy Department of General Electric Co., Carborundum Co., Cavitron Equipment Co., Chrysler Corp., Cincinnati Milling Machine Co., Elox Corp., Ex-Cell-O Corp., Fenlind Engineering Co., Firth Sterling Steel & Carbide Corp., Ford Motor Co., Frankford Arsenal, Hammond Machinery Builders, Inc., Kennametal, Inc., Minnesota Mining & Mfg. Co., Norton Co., Precision Diamond Tool Co., Raytheon, Inc., Super-Cut, Inc., Watertown Arsenal, Wickman Mfg. Co.

ple, production of cemented carbides jumped 62% in the short space of two years (1951 to 1953). The U.S. is wholly dependent upon imports for diamond bort – the crushed material used in making diamond wheels for grinding milling cutters, broaches, fluted tools, chip breakers and single-point tools with cemented carbide inserts. While there has been a marked increase in shipments of bort, it is touch and go whether the supply can keep pace with rising consumption. Hence the importance of alternative processes and machines for tool grinding, and of conservation and reclamation of diamond bort.

About 70% of all diamond bort is consumed in shaping and finishing cemented carbides. Over the past few years a definite shift has been noted to machining and grinding of nonmetallics, although the magnitude of this change is only about 5% of the total. It is predicted by some sources that the current supply of diamond bort – something over 9,000,000 carats annually – could eventually be used entirely in the nonmetallic field, if the need were not urgent for the material in grinding carbide tools.

New Machining and Grinding Processes

The original MMAB report covered four alternative methods for machining and grinding hard materials, circumventing the need for diamond wheels. They were: electrolytic, electro-sparking, electro-arcing and ultrasonic. Two other alternative and more conventional processes now have been judged worthy of inclusion – silicon carbide belt grinding and silicon carbide wheel grinding – and there have also been noteworthy improvements in diamond wheel grinding, leading to conservation. Therefore, a regrouping of all processes into six classifications appears in order. The new list is:

1. Electro-discharge processes (including electro-sparking and electro-arcing).
2. Electrolytic processes.
3. Ultrasonic abrasive grinding.
4. Silicon carbide belt grinding.
5. Silicon carbide wheel grinding.
6. Diamond wheel grinding.

Research on each of these six processes breaks down into three areas – basic research, machine and process development, and field tests. In recent years, most attention has been concentrated on the latter two phases. The present investigational work is directed 43% to the field of sharpening single-point carbide tools, 21% to shaping and finishing dies, 12% to chip breaker grinding, 10% to sharpening milling cutters, broaches and fluted tools, 8% to surface, cylindrical and internal grinding of carbides, 4% to the glass industry and the balance to miscellaneous applications. Naturally there is some overlapping since results achieved in one classification may easily affect progress in others.

The electro-discharge process has been used experimentally in a multitude of operations during the past two years. Since it is peculiarly adapted to drilling small, deep holes for complicated shapes, developments are emphasized for operations most suitable for the machines involved. The techniques currently are being centered on shaping and finishing the hard-to-machine high-temperature metals and alloys proposed for jet-engine components. The potentialities of commercial applications in this work are enormous.

The electrolytic processes are no longer experimental, and units for sharpening single-point tools and chip breaker grinding could move rapidly into production. Combinations of vitrified-bonded diamond wheels with electrolytic assist for off-hand grinding of single-point carbide tools (*Metal Progress*, May 1953, p. 198) have demonstrated possible savings of 80 to 90% in diamond bort. Electrolytes, including sodium nitrite-nitrate and sodium silicate types, have been the subject of extensive study, along with methods for introducing electrolytes to the work area. A further related research here has been in electronics, for developing rectifier power units to minimize arcing and to permit much higher current densities.

Approximately three times as many ultrasonic abrasive grinding machines are now in operation as in 1951. Some are in full production; others are undergoing intensive field analysis. Advances have been made in experimental work on ultrasonic grinding for sharpening single-point tools and grinding chip breakers, but these have not moved into the field test stage.

Silicon carbide belt grinding is of comparatively recent origin for finishing single-point tools; more than 300 machines were installed in 1953 for this purpose. The technique still is limited to final finishing operations on the tools and small areas of grinding, with roughing operations usually done by silicon carbide wheels. Improvements in grains, bonds, machines and general operating methods offer the most profitable opportunities for further development.

Silicon carbide wheel grinding appears limited to uses where the volume of grain in the wheel is high compared to the area of work being ground.

Diamond Turning. (Courtesy Bausch & Lomb Co.)

As mentioned, it is being used widely for roughing operations on single-point tools. Grinding relatively small areas of cemented carbides with a narrow, small-diameter wheel is not promising, because of relatively high wheel wear. More extensive use of the green silicon carbide grain has been a significant step ahead in this field, while there have been concurrent improvements in bonds and in techniques for applying coolants. An example of the latter is the introduction of coolant through a porous wheel.

More efficient use of diamond wheels in all forms of tool grinding is a worth-while contribution to bort conservation. An example is the so-called plunge-cut method, using narrow diamond grinding wheels to machine-cut, in one pass, as deep as 0.1 in. More extensive and intelligent application of coolants, together with better bonding materials and improved methods of inserting grains, are other forward steps. Single-layer diamond wheels are now undergoing field tests for finishing single-point tools, where fine diamond powder is involved.

Economics and Performance

Data on the economics and performance of these six processes, while somewhat deficient from the quantitative standpoint, have been assembled from analysis of field tests and the experience of production shops. The resulting broad qualitative evaluation is summarized in Table I. No attempt is made to weight the various cost items since they vary with specific applications—electrical power, for example, being the lowest of the group. Items listed under the heading of performance refer to the performance of the machines for removing stock and not of the as-shaped and finished pieces. Some of these factors are reflected in economics. Thus, rate of cutting partly determines direct labor costs; and checking and cracking will have a bearing in the sense that a high risk will cause more rejects.

Trade acceptance of the new processes in some instances is more of a hurdle to be cleared than is the lack of technical information. Industry

Table I – Cost and Performance Data for New Machining and Grinding Process*

Item	Electro-Discharge	Electro-lytic	Ultrasonic Abrasive	Silicon Carbide Belt	Silicon Carbide Wheel	Diamond Wheel
Costs						
Capital investment (*a*)	H	M	H	L	L	L
Supplies	L-M	L	L-M	L-H	M-H	M-H
Direct labor	L	L	L	L-M	L-M	L
Maintenance	L-M	L-M	L-M	L	L	L
Electrical power (*b*)	L-H	L-M	L-H	L	L	L
Performance						
Finish, rms. (*c*)	P-G	F-G	P-G	F-G	F-G	F-G
Precision	P-G	F-G	P-G	F	F	G
Rate of cutting	L-H	H	L-M	L-H	L-H	H
Versatility (*d*)	F	G	F	P	G	G
Automatic operation (*e*)	H	L-M	M-H	L	L	M
Operator skill	L-M	M	L-M	L	L-H	L-H
Checking, cracking (*f*)	L-H	L	L	L	M-H	M
Edge quality (*g*)	P-G	F-G	P-G	F	F	G

*The letters in this tabulation generally have the following meaning: H — high, M — medium, L — low, P — poor, G — good, F — fair. Where range is shown, reference is to different applications. More specific meanings are given in the following footnotes.

(*a*) H — more than $5000 per machine; M — $1500-$5000; L — less than $1500.

(*b*) H — more than three times conventional wheel grinding; M —two to three times; L — same range as conventional wheel grinding.

(*c*) G — less than 10 rms.; F — 10 to 25 rms.; P — more than 25 rms. Root mean square (rms.) is roughness in micro-inches as measured by profilometer.

(*d*) Refers to ease of adapting same set-up to different types of operations.

(*e*) Process rated "L" (for low) requires most operator attention.

(*f*) H — high risk of checking and cracking; M — moderate risk; L — low risk.

(*g*) Refers to sharpness of tool edge rather than actual performance.

is understandably reluctant to accept a new process until it has been fully proved, and this takes time. In addition, better acceptance is accorded machines that are only modifications of existing types, which explains the ready acceptance of silicon carbide belt and wheel grinding.

An attempt to chart the technical applicability of each of the processes is made in Table II. It is apparent that some of the newer processes have definite advantages over diamond wheel grinding. For drilling small-diameter deep holes, embossing and tapping, the electro-discharge and ultrasonic methods can do the job where diamond wheel grinding cannot. Classifications in this table are not intended to show the degree of effectiveness for the operations listed, questions of economics and performance being given no weight.

Initial capital equipment investment inferred by some of the new processes may well be prohibitive for the small shop. Advanced methods of diamond wheel grinding, silicon carbide wheel and belt grinding are less expensive as far as equipment is concerned, and even though they are not so economical for high production rates (in terms of unit cost), they should meet the needs of the smaller operators and hence their development should be encouraged.

Machines based on newer principles, such as the electrolytic, electro-discharge and ultrasonic equipment, may have potentials far beyond conventional methods and, for the larger company, may have productive capacity that overbalances the higher initial investment and lack of general trade acceptance.

Some manufacturers are now placing a few of these new machines in their production lines (replacing only a small fraction of the total machining and grinding facilities), admittedly as a means to gain knowledge of operating characteristics and potentials. If a sudden need for a shift away from conventional methods should arise, these firms should be in a good position to make it.

The pattern of research and development, from the stages of conception to production, is deficient in respect to field performance tests. After a machine is developed to the point where it is ready for such tests, it is often sent directly to a production shop, for operation by production personnel, making a leisurely and thorough quan-

Table II – Applicability of Processes*

Materials and Operations	Electro-Discharge	Electro-lytic	Ultrasonic Abrasive	Silicon Carbide Belt	Silicon Carbide Wheel	Diamond Wheel
Cemented carbides	√	√	√	√	√	√
Metals	√	√	√	√	√	×
Nonmetals	×	×	√	√	√	√
Large areas (*a*)	√	√	×	√	?	√
Small areas (*b*)	√	√	√	√	√	√
Small-diameter deep holes	√	×	√	×	×	×(c)
Cutoff	√	√	√	×	√	√
Embossing	√	×	√	×	×	×
Off-hand grinding	√(d)	√	?	√	√	√
Fixed feed	√	√	√	√	√	√
Form grinding	√	√	√	×	√	√
Tapping	√	×	√	×	×	×

*A check mark (√) means that the process is technically capable of machining and grinding those materials indicated and performing the other operations listed; a cross (×) indicates that it is not.

(*a*) More than 4 sq. in.

(*b*) Less than 4 sq. in.

(*c*) Loose diamond powder can be used for small-diameter deep holes, but wheels cannot.

(*d*) Recent developments indicate that off-hand grinding by electro-discharge techniques is practical but as yet it has not been fully proved in the field.

titative study of its operation difficult. It is suggested that machines might go into the field at rather early stages of their development to permit more complete performance tests on specific applications.

Conservation and Reclamation

It is of corollary interest to examine the progress that industry is making in the improvement of grinding practice to prolong the life of diamond abrasive wheels and thus conserve diamond bort requirements, and in salvaging waste materials from grinding operations to reclaim diamond fragments. Such an effort has been made in a separate panel report, MAB-55-C.

Improved grinding practice covers such measures as limiting the use of diamond abrasive to those jobs where other types of abrasives are inefficient or uneconomical, greater care in trueing and dressing of diamond wheels, matching the surface speed to the type of wheels employed and the character of material being processed, reducing wheel vibration, and application of coolants wherever possible.

The nature and value of diamond-bearing wastes are dependent in part upon the bonds used in the wheel and the grit sizes thereof, but chiefly upon the composition of the materials being machined and ground. To insure the optimum concentration of diamond fragments in machine swarf and sludge, self-contained portable collecting units should be attached to the grinding machines using diamond wheels, in order to segregate diamond-bearing waste from that coming from other types of abrasive wheels.

Both physical and chemical methods have been devised to reclaim diamond particles from sludge. The former include screening and sieving, electrostatic separation and flotation. Chemical removal of most of the impurities present, however, is essential. Treatments include addition of oxidizing agents, decomposition with one or more acids, fusion with potassium hydroxide and various sodium salts, and removal of volatile impurities with hydrofluoric acid.

Diamond content of swarf and sludge currently being produced may vary from ½ to 50 carats per lb., while the size of particles ranges from 40 mesh down to less than one micron. Material as fine as 325 mesh is recovered fairly readily; smaller particles present greater difficulties, and submicron sizes largely defy recovery. At present diamond prices, sludge containing as little as 3 carats per lb. may be processed economically and most of the diamond content recovered.

Potential salvage of industrial diamonds is estimated at from 1,500,000 to 3,000,000 carats annually. In 1950, only 685,000 carats were reclaimed and in 1953 probably close to 1,000,000 carats. In normal times, the realistic figure for salvage is about 20% of the total powder used. In times of emergency, with foreign shipments possibly curtailed, the salvage percentage could be appreciably higher.

Short Runs...

Heat Treating

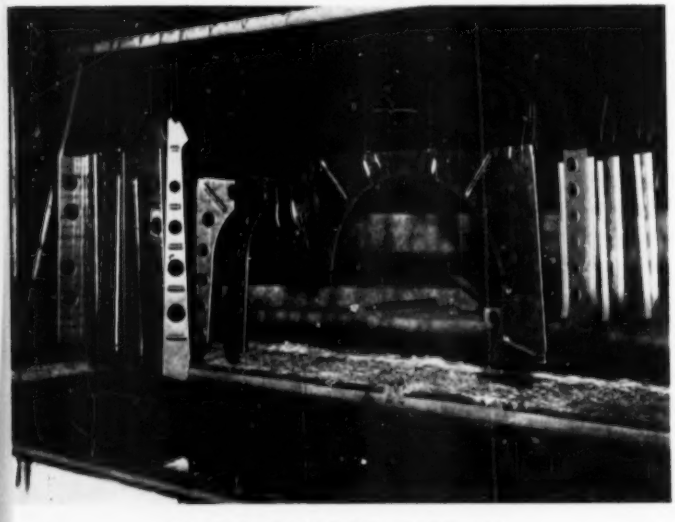
THE METHOD devised by the Glenn L. Martin Co., Baltimore, Md., for handling aluminum parts during heating and quenching has reduced the amount of distorted work by 90% and has cut the time for the operation by 40%. Instead of using baskets to hold the parts, they are suspended by a stainless steel wire from a long pole that has short projecting pins from which the looped ends of the wires are hung. The pole is a part of a unit that can be moved from tank to tank in the process.

The pipe is equipped with a counterbalance that causes it to rotate when a trigger is released by the operator and the suspended parts drop off the pipe into the bath.

In the first stage of the operation, the pipe with the parts attached is lowered until the parts are immersed in the salt bath. After a predetermined period in this tank, the pipe is raised, and the unit is moved over the cold water bath where the pipe is rotated to release the parts. After quenching, a basket previously placed in the cold water tank is lifted and the parts are removed.

An additional advantage of this method is that the nitrate salt does not need to be replenished so often because there is no large basket to cause drag-out. Also, the time required in heating and quenching is shortened because no heat is lost on extraneous material.

Parts Suspended From the Rotatable Pole From Which They Are Released During Quenching. (Courtesy Glenn L. Martin Co.)



Coatings

Much is known already of the value of the anodically produced hard coatings on aluminum and its alloys for resistance to wear, corrosion and heat. The thickness of these oxide coatings can be varied from 0.001 to 0.005 in., although most light engineering requirements can be met by coatings of 0.001 to 0.002 in.

Some investigations have been carried out in England, the findings of which are given in a recent unpublished Ministry of Supply report, with a view to discovering a simple and economical modification of the well-known sulphuric acid process to produce desired coatings. An important requirement has been found to be a cold electrolyte—about 32° F. The anodizing cell may simply be surrounded by ice to achieve this temperature. A current density of 45 amp. per sq.ft. in 5 or 10% sulphuric acid electrolytes can give hard anodic coatings between 0.002 and 0.005 in. thick on aluminum and a number of its alloys. Anodizing for 14 to 19 min. produces 0.001 in. of coating.

Stronger electrolytes and higher temperatures, particularly above 60° F., reduce the rate of growth, the hardness and the abrasion resistance of the coatings. Brittle coatings will form if the tank is cooled below 23° F., the effects increasing with time.

Agitation of the electrolyte is necessary to keep the anode cool. For thicker coatings or difficult parts, internal cooling of the anode might be employed with benefit.

Some comparative abrasion tests on coatings produced by this method on similar alloys in England, as against two coatings produced by an American hard anodizing process on 6061-T6 (61S-T6) and 7075 (75S) alloy sheets, showed a superiority of the coatings produced by the technique just described.

The information given in this item is by permission of the (British) Ministry of Supply.

Pickling

The nuisance of replacing the wear stone on a pickling tank that was soon worn through by wire traveling through the bath was corrected by John A. Roebling's Son Co. by using wear stones of silicon carbide. The silicon carbide, supplied by the Carborundum Co., showed practically no wear when the photograph above was taken after six months of service.

Painting of Aluminum and Magnesium

*By ROBERT I. WRAY**

Surface preparation, selection of primer and finish coats and methods of their application.

THE PROCEDURES for painting aluminum and magnesium alloys are somewhat different from those for painting steel, and they also differ for the two groups of alloys; however, the types of paint protection required on the various light-metal alloys have much in common. The greatest divergence in painting practices lies in the manner in which the surfaces must be prepared for painting. The kind of surface preparation selected will vary to some extent with the conditions of service. Since different types of surface treatment are employed on aluminum and magnesium-base alloys, each treatment should be considered separately.

Aluminum Alloys – Surface preparation for painting is almost as important as selecting the correct paint. Although paint adherence varies

*Chief, Paint Finishes Div., Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.

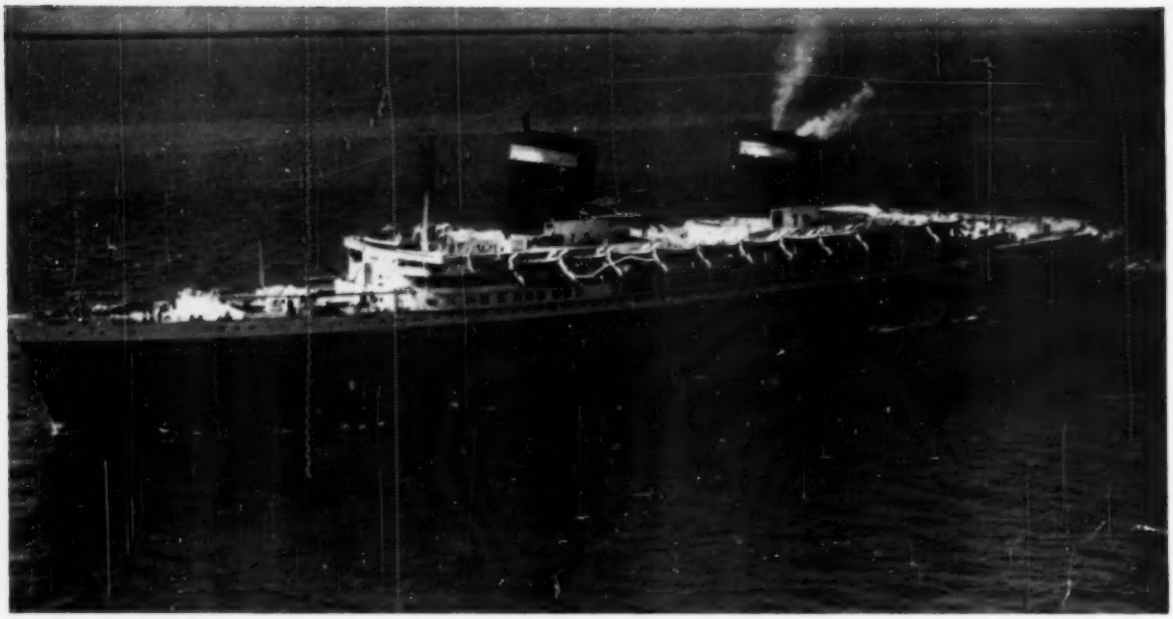


Fig. 1 – Practically the Entire Superstructure of the S.S. United States, Including the Funnels, Was Constructed of Aluminum, Primed With Zinc Chromate and Finished With Alkyd-Base Enamels

with the alloys of aluminum, this difference can be minimized with correct treatment. The methods of surface preparation are usually common to all aluminum alloys. Paint performance is usually better on alloys such as 1100 (2S), 3003 (3S), 6053 (53S), 6061 (61S), and the Alclad alloys than on 2017 (17S), 2024 (24S), and 7075 (75S), because of the inherently better corrosion resistance of the former.

The simplest surface treatment is solvent cleaning, which is adequate for some applications. Solvent cleaning with a swab or brush is the least effective and should be employed for only the least critical service conditions. Cleaning by dipping in a solvent is only slightly more effective than hand cleaning. Solvent-vapor degreasing overcomes many of the objections to other forms of solvent cleaning, and for some applications is adequate.

Mechanical methods of surface preparation are not as effective on aluminum alloys as on steel, so they are seldom used. In a few instances, however, surface roughening, as by wire brushing, has improved paint adherence especially when used in conjunction with a chemical treatment. Sand-blasting is applicable only to thick sections because of the danger of warpage, and even here, it is seldom used.

Some form of chemical treatment is the most commonly accepted method of properly preparing aluminum alloy surfaces for painting. Alkaline cleaners that contain inhibitors to prevent attack of the aluminum are sometimes employed to remove grease from the surface of the metal. Sodium carbonate or trisodium phosphate, inhibited with sodium disilicate, is most commonly used for this type of cleaning. Inhibited alkaline cleaners are usually employed as pretreatments to an acid-type treatment, since by themselves they do not generally give a surface that is satisfactory for painting.

One of the simplest chemical treatments is the cold aqueous solution of phosphoric acid mixed with certain organic grease solvents and emulsifying agents. There are a number of proprietary mixtures of this type. They are usually sold as concentrated solutions and should be diluted with two or three parts of water prior to use. The surface of the metal should be swabbed or brushed with the diluted solution which should be allowed to remain on the metal for about 5 to 10 min.; the surfaces should then be thoroughly rinsed with clean water and allowed to dry before painting. A phosphoric acid treatment applied in this manner is highly effective for use under a wide variety of service conditions. When the surface to be treated is excessively oily or greasy, it is desirable to first pre-

clean it, either by solvent vapor degreasing or with an inhibited alkaline cleaner.

Hot chemical treatments, such as Bonderizing, Alodizing and the Alrok process, are frequently desirable when product finishes are applied. The time of processing is shortened; therefore the entire operation of treating and painting can be carried out at a faster rate. Treatments of this type usually require special equipment such as dip or spray tanks, a conveyer line or drying ovens. The treatments are usually carried out at temperatures ranging from 140 to 170° F. They are multistep processes involving a preliminary precleaning and rinse, chemical treatment, rinse and finally an acidulated rinse.

Anodically produced oxide coatings on aluminum are also sometimes used as surface treatments prior to painting. The Alumilite* process is an example of this method. The thick protective oxide coatings that are produced form an excellent base for paint.

The so-called "wash primer metal conditioning treatment" is usually classed under surface preparation methods although it is film-forming as are other primers. Before the wash coat is applied, it is usually necessary to degrease the metal surface. Phosphoric acid is generally added to the primer just before use. The resin contained in the primer is made insoluble by the acid which reacts with it, as well as with the pigment (usually basic zinc chromate) and the metal surface. This reaction produces a hard, adherent coating and promotes good adherence to subsequently applied coatings. This conditioning treatment may also be employed on magnesium-base alloys.

Surface Preparation of Magnesium Alloys

Before any surface treatments are applied on magnesium alloys preparatory to painting, some form of cleaning is usually required in order to remove dirt, oil, grease or other contaminants. While solvent cleaning or solvent vapor degreasing may sometimes be sufficient, it is usually desirable to follow solvent cleaning with alkaline or acid cleaning, or both. The more highly alkaline solutions such as are used on steel are more effective cleaners for magnesium than the inhibited alkaline solutions for aluminum. Acid cleaners are recommended only when it is necessary to remove oxide, corrosion products, burned-on drawing compound, forging lubricants, or old chemical coatings. Two types of acid cleaners are used, etching and nonetching. Sulphuric acid or nitric-sulphuric acid solutions will remove surface contaminants from sand castings that have been cleaned by sand-blasting. Chromic acid solutions, however, do not remove any metal and may, therefore, be safely used on parts that have been machined. Parts to be cleaned in this solution are immersed from 1 to 15 min. at a temperature of 180 to 200° F., whereas the bath of sulphuric or nitric-sulphuric acids is operated at room temperature.

Following the preliminary surface cleaning of the magnesium, various chemical surface treatments may be applied. One of the most widely used treatments is the so-called "chrome-pickle", the bath for which consists of a strong aqueous solution of sodium dichromate and nitric acid. This treatment is applicable to all magnesium-base alloys, except that for wrought alloys, a small amount of magnesium sulphate is added to the solution to prevent intergranular attack. The solution, which may be used at room temperature or at 150° F., produces a yellow or yellow-red iridescent color on the metal. The value of this treatment for painting is in its ability to passivate the surface and at the same time produce an etching effect (about 0.001 in. of metal is removed). The coating formed by this treatment is sometimes "sealed" by immersing the treated parts for 30 min. in a boiling solution containing 10 to 20% by weight of potassium, sodium or ammonium dichromate, followed by thorough cold and hot water rinses. The coating so produced is referred to as "sealed chrome-pickle", and is recommended where service conditions are severe.

Another surface treatment that has excellent protective value is the hot dichromate treatment. It is one of the most effective of the chemical treatments and is suitable for use on all magnesium-base alloys except the wrought alloy containing 1.5% manganese. The treatment consists of two steps. First, the parts are immersed for 5 min. in a dilute aqueous solution of hydrofluoric acid or sodium, potassium or ammonium fluoride and then rinsed in cold water. They are then held for 30 min. in a boiling aqueous solution of sodium dichromate, plus calcium or magnesium fluoride, followed by thorough rinsing. This treatment produces a dark brown to black coating.

Several anodic treatments are also applicable to magnesium-base alloys. One type is known as the galvanic anodic or galvanic dichromate treatment. The parts are first immersed in the fluoride bath previously described and after

*Patented process of Aluminum Co. of America.

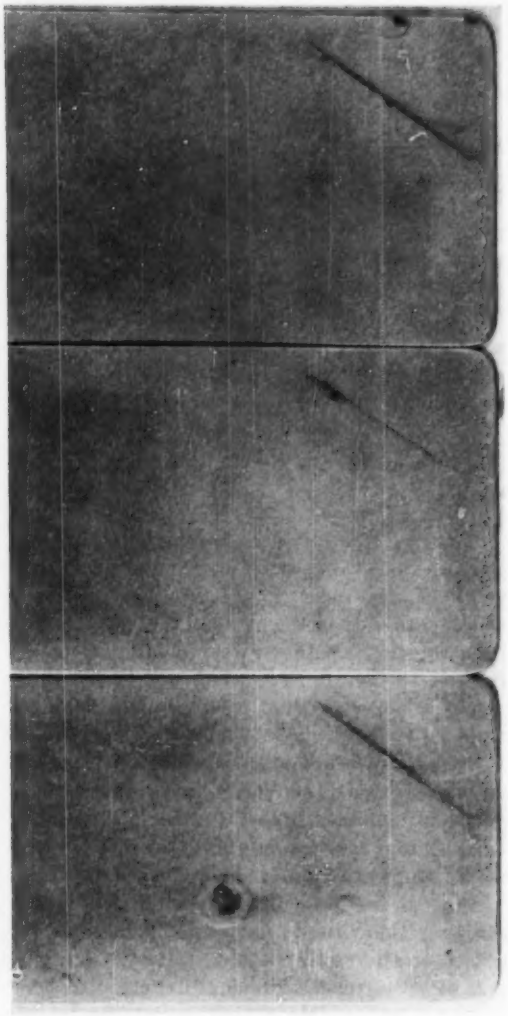


Fig. 2 – Painted Magnesium Alloy Panels (AM-C 52 S-H) After Exposure for 46 Weeks to Accelerated Testing in Outdoor Alternate Immersion in Salt Water. Panel at bottom primed with zinc chromate, center with calcium chromate and top with strontium chromate, all in phenolic vehicle, and finished with three coats of aluminum paint

rinsing they are anodically coated in a bath containing ammonium sulphate, sodium dichromate and ammonia for a period of 30 min. at an elevated temperature. The resulting coating is black in color and has good protective properties. Paint adheres well and this coating is applicable to all alloys of magnesium.

Another type of anodic coating is formed in a dilute caustic soda solution (7 oz. of caustic soda per gal. of water). The bath is maintained at room temperature and coating requires 30 min. After coating, the parts are thoroughly rinsed in cold water and are then sealed in a 5% solution of sodium chromate maintained at 170 to 180° F. for 30 min. This treatment, applicable to all alloys, produces a gray to bronze-colored coating which is protective and ranks high as a base for paint.

A new type of anodic coating recently developed at the Frankford Arsenal is known as the HAE coating*. The HAE treatment produces a hard, nonmetallic coating on the metal surface from one to two mils thick. Tests have indicated that the HAE coating increases the corrosion resistance of magnesium alloys to salt spray. The coating has certain limitations, however, because of its hard, inelastic nature and should, therefore, be used only on rigid surfaces and not on parts to be subsequently machined or worked.

Primers for Aluminum and Magnesium Alloys

Selection of a primer for the light metal alloys is governed to a great extent by the specific application of the part. For the more severe service conditions, the primer should contain a pigment with good corrosion-inhibitive properties and be made with a vehicle showing good resistance to moisture penetration. For this kind of service, zinc chromate primers made with synthetic resin vehicles have been found to be most effective. A number of government specifications cover primers of this type. The rapid-drying zinc chromate primers meeting military specification MIL-P-6889a have been widely used in priming both aluminum and magnesium-base alloys for many applications including aircraft structures.

The alkyd-base zinc chromate primers that meet government specification JAN-P-735 have been found to give excellent results for aluminum, particularly in marine applications. A number of commercial primers of these types are available, some of which are designed for use on either metal while others are specifically designed for use on magnesium. It is especially important in the case of the latter that the primer contain a high percentage of zinc chromate; medium oil length phenolic-resin-base varnishes are especially recommended as vehicles. Baking of the primer on magnesium has been found to increase its effectiveness still further.

Vinyl-base primers are recommended for use over the wash coat. These primers are made

*Described in *Metal Progress*, Vol. 62, September 1952, p. 81.

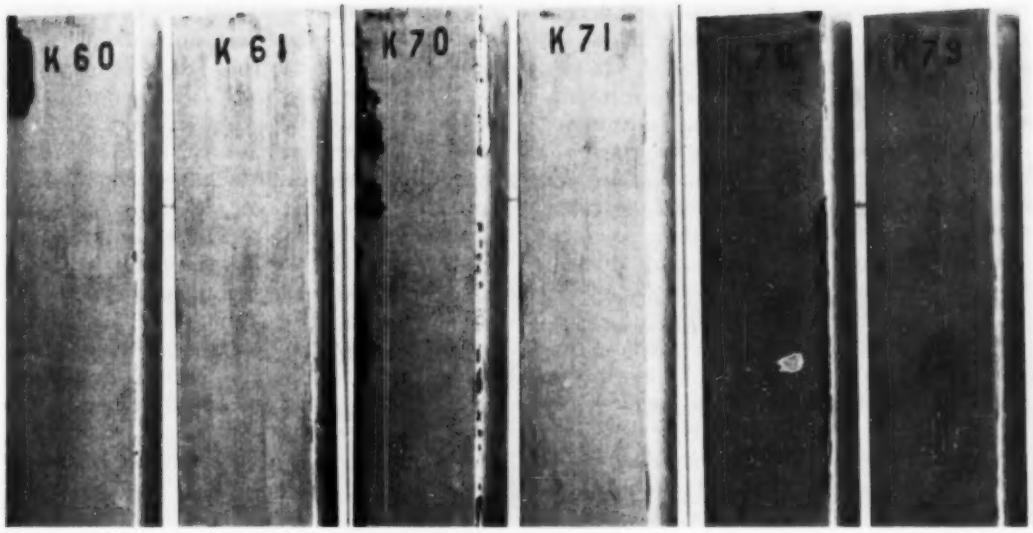


Fig. 3 – Structural Aluminum Channels Primed With Zinc Chromate and Finished With Aluminum Paint, After Exposure to the Atmosphere at New Kensington, Pa., for 8 Years. Even-numbered channels were solvent cleaned, odd-numbered channels treated with phosphoric acid solution

with special vinyl resins that show particularly good adherence to the wash coat. Tests have shown that vinyl-base primers pigmented with aluminum powder are especially effective for some applications. Where the metal is to be immersed in salt water, however, a primer pigmented with zinc chromate is preferred.

Many applications do not require the use of primers having high corrosion resistance. Here, the primary purpose of the primer is to serve as a bonding coat between the metal and the finish coats. It must have good adherence to the metal surface and permit good adherence of the finishing coats to itself. For applications in atmospheres not contaminated with corrosive fumes, the metal surface may be primed with any good grade of metal primer not containing lead pigments. Exposure tests have established the fact that the heavy metal salts react with aluminum or magnesium to form deposits of some of the heavy metal, such as lead, upon the surface. Pitting of the surface results if it is kept wet for an extended period.

The use of special primers may sometimes be eliminated where painting is done largely for appearance, as on interior applications. Synthetic resin enamels having good adhesion to metal surfaces should be used for this class of items. The number of coats required will be governed by the desired appearance. For household appliances on which baked finishes are more suitable, special baking-type primers are used. These primers are frequently made with alkyd-base vehicles pigmented to suit the desired finishing coats. For example, under white enamels, such as are used on refrigerator parts, a white pigmented primer (usually containing titanium pigments) should be employed. Under dark finishes, primers pigmented with iron oxide are satisfactory. When vinyl finishes are to be employed, a primer that will not be affected by the solvents in the vinyl coating must be used. Here again, specially formulated synthetic resin primers are available for this use.

Where service conditions are severe, it is desirable to prime individual parts of an assembly before they are joined. If aluminum or magnesium are to be in contact with a dissimilar metal such as copper or steel, special precautions must be taken to avoid galvanic action. In addition to one or more coats of primer on the faying surfaces of the two metals, a special sealing or caulking compound should be employed. A satisfactory sealing compound for this purpose must be highly resistant to moisture and should not become brittle in service. A number of commercial sealing compounds and tapes are available which fulfill these requirements.

Finishing Coats of Paint

The function of a finishing coat is to protect the primer and afford long life to the paint sys-

tem, so the choice of finishing coats will depend in large measure upon the severity of the exposure to which the metal is subjected. In general, finishing coats of paint which are suitable for use on other metal surfaces may be employed on aluminum or magnesium. The finishing coats must be compatible with the primer and should have good adherence. Best results are often obtained with the primer and finishing coats that contain vehicles of similar composition, although this is not entirely essential if the two paints are compatible.

Finishing coats made with synthetic-resin-base vehicles of the alkyd or phenolic-resin type are especially suitable for use under conditions of severe exposure. Paints of this type show high resistance to the passage of moisture and have good resistance to many chemical fumes. There are a number of government specifications describing such paints. The pigmentation of the finishing coats will, of course, depend upon the color scheme desired. Aluminum paint made with a synthetic-resin-base vehicle has been found to be an excellent finishing coat where its color is acceptable.

Vinyl-base finishing coats are also effective over a suitable primer made with a vinyl resin. Systems built up with, first, a wash coat (the metal conditioning treatment), then a vinyl-base primer, and finally finishing coats containing vinyl resins have given good results in protecting light-metal alloys.

For less severe service requirements, the qualifications of the finishing coats are less exacting, and a protective finishing paint of a good grade is satisfactory. Of course, longer life will be obtained with the more durable synthetic-resin-base enamels, alkyd finishes being particularly recommended. Pigmented lacquers may also be used if they are applied over a suitable primer, such as one meeting military specification MIL-P-6889a.

Frequently, fewer finishing coats are required for aluminum than for steel, even though the degree of protection desired still governs the number of finishing coats that will be applied. The requirements for finishing coats on magnesium are similar to those for painting steel; no less than two coats should be used for outdoor service, and where conditions are severe, three finishing coats are suggested.

Baked Finishes

The use of finishes that are force-dried or baked is advantageous because it speeds the finishing operation. Then, too, the baked finishes are usually more durable than air-dried finishes and have greater hardness and abrasion resistance. Most of the modern baking finishes are of the synthetic resin type, made with either alkyd, alkyd-urea or phenolic resins, designed especially for baking. Vinyl and epoxy resin finishes are also sometimes used for this purpose, particularly where a high degree of alkali resistance is desired. Baking schedules will vary with the finish selected, ranging from 250 to 400° F., and for different time intervals. Baked finishes made with phenolic-resin-base varnishes have been found especially suitable for protecting magnesium alloys under the more severe conditions of service, such as salt atmosphere. Baked alkyd or alkyd-urea finishes are widely used on aluminum.

Where a high degree of chemical resistance is required, coatings formulated with heat-reactive phenolic resins give excellent results on both aluminum and magnesium. They are usually applied in multiple coats, each coat being baked individually. Usually, the undercoats are baked at a lower temperature than the final coat, which may be baked for an hour or more at 350° F. to insure complete reaction of the resin. Vinyl-base coatings and epoxy resin coatings are also used for their chemical resistance, as was previously indicated.

Methods of Application

Paint coatings may be applied to aluminum and magnesium-base alloys following the same technique employed for the painting of other metals. The methods used include brushing, spraying, dipping and roller coating. The choice of method of application will depend on both the surface to be coated and the type of finish selected. Spraying is probably the method most widely used on large surfaces, while dipping is frequently employed for small parts. When parts are to be formed from flat sheet, the sheet is often precoated by means of machine roller coating. In this case a coating must be applied that will withstand subsequent forming operations. The coatings on bottle caps and containers are applied in this manner and subsequently baked.

The wide variety of uses to which the light alloys are placed demands a large number of types of coatings and methods of application. Each job should be carefully considered before selecting the coating and the finishing method to be employed.

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Personal Mention

Louis H. Winkler

LOUIS H. WINKLER, metallurgical engineer with Bethlehem Steel Co., Bethlehem, Pa., was conferred the highest honor of the American Society for Testing Materials when he was given an honorary membership at the last annual meeting. Following graduation from the University of Missouri (B.S. in 1907, M.E. in 1909), Mr. Winkler joined Cambria Steel Co. in Johnstown, Pa., remaining with the company through its consolidation with Midvale Steel and Ordnance Co., and its acquisition in 1930 by Bethlehem Steel. He has been concerned with a variety of steel products, but much of his work has been in fields of wire and wire products and piping and tubular products. In addition to serving on numerous ASTM committees and subcommittees, he has served as chairman and member of several American Iron and Steel Institute committees, member of the American Standards Association award committee, council, and committee on procedure, Metals Handbook Committee from 1951 to date, and two American Petroleum Institute committees. Mr. Winkler is also a member of the Society of Automotive Engineers, American Railway Engineering Association, Technical Board of the Wrought Steel Wheel Industry, and the Wire Rope Technical Board.

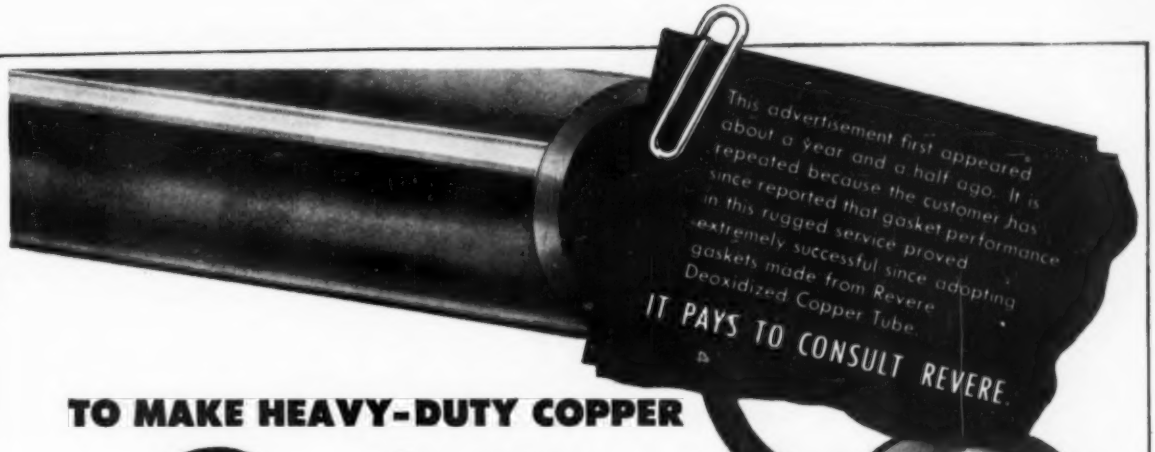
John W. Bolton

JOHN W. BOLTON, who has directed the metallurgical research and testing division of the Lunkenheimer Co., Cincinnati, Ohio, for the past 27 years, has retired as chief metallurgist and research director. Since joining the company as chief metallurgist in 1926, his department has developed and patented many unusual bronze, iron and steel alloys, as well as several special processes. Mr. Bolton was active in the technical affairs of the American Foundrymen's Society, and was first chairman of the gray iron and nonferrous division. On the basis of published research work (a book on "Gray Cast Iron" and more than 60 technical papers) he was awarded the John A. Penton Gold Medal of the American Foundrymen's Society in 1937. He has been often honored for his long and outstanding record in developments in various fields of foundry metallurgy and in practical applications of research findings to the advancement of the castings industry. Mr. Bolton graduated from Rose Polytechnic Institute with a B.S. degree in 1918, and received his M.S. three years later. He is also a member and former national director of the American Society for Testing Materials, the American Institute of Mining and Metallurgical Engineers, the Manufacturers Standardization Society of the Valve and Fittings Industry, and the American Welding Society. Mr. Bolton's well-earned retirement gives him time to devote to his hobbies of pigeon breeding and rifle shooting. He hopes to spend much of his leisure time on his farm near Terre Haute, Ind.

Marvin L. Steinbuch has been appointed successor to **John W. Bolton** as chief metallurgist and research director at the Lunkenheimer Co., Cincinnati. A member of the company's metallurgical research and testing division since 1947, Mr. Steinbuch graduated from the University of Cincinnati in 1943 with a bachelor's degree in chemical engineering and received a master's degree in 1947.

Nicholas C. Jessen has been named assistant superintendent of the Barberton, Ohio, works of the Babcock & Wilcox Co.'s Boiler Div. Mr. Jessen joined the company in 1930 at the Bayonne, N. J., works, and was transferred to the Barberton plant in 1932 where he has served in the capacity of chemist, metallurgist, welding engineer and assistant director of the works laboratory. During the past two years, Mr. Jessen has had two assignments in Europe where he observed heavy forging practice, steel production, welding and boiler fabrication methods. He was also an instructor in metallurgy in the evening classes at the University of Akron for four years.

James P. Hontas has been appointed staff metallurgist for the American Society for Metals. He was graduated as a metallurgical engineer from the Colorado School of Mines and holds a degree in business administration from Fenn College. In 1942, Mr. Hontas was employed by the Goodyear Aircraft Corp., Akron, Ohio, for 3½ years. In 1946, and for five years thereafter, he was research and development metallurgist for the Cleveland Graphite Bronze Co. Since 1951, he has been with Clark Controller Co., Cleveland, as materials engineer. Mr. Hontas' diversified experience in the metalworking industry will be of specific value in his work with technical committees preparing reports for the next editions of Metals Handbook.



TO MAKE HEAVY-DUTY COPPER

Gaskets

USE REVERE DEOXIDIZED

Tube!

Diesel Fuel Injection Pump, made by American Bosch Corp., Springfield, Mass., and gaskets made by cutting rings off 2" deoxidized copper tube.

• An important extra service rendered by Revere consists of collaboration in setting up specifications. This is valuable because there are many different Revere Metals, each with special characteristics. No one copper, for example, will serve to best advantage in every application. A case in point is the matter of copper gaskets for Diesel fuel injection pumps. Copper is of course an ideal metal for gaskets, and is widely used for that purpose. But for this special application, which copper and in what form? The pump is used on large engines for municipal generating plants. It weighs 186 pounds, and must produce the high pressure required to inject fuel near the top of the Diesel compression stroke. Naturally, the load is a pulsating one. American Bosch Corporation came to Revere with the problem. Our suggestion was that much scrap could be saved if the gaskets were made by cutting rings off copper tube, instead of stamping them from strip. This achieved a double purpose, since the tube is made of deoxidized copper, which is superior in this application to electrolytic. We are able to report that these recommendations proved successful. . . . This work was done by the Revere Technical Advisory Service. To get in touch with it, see the nearest Revere Sales Office.

REVERE

COPPER AND BRASS INCORPORATED

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SEE "MEET THE PRESS" ON NBC TELEVISION, SUNDAYS

Personals . . .

J. Walter Gulliksen was recently appointed general manager of Chase Brass & Copper Co., a subsidiary of Kennecott Copper Corp., in Waterbury, Conn. Mr. Gulliksen, a graduate engineer from Stevens Institute of Technology with a degree in mechanical engineering, has also completed post-graduate work at New York University, Rutgers Extension University, Stevens Institute of Technology, and Worcester Polytechnic Institute in many subjects, including commercial law, industrial personnel management, metallurgy and powder metallurgy. He served 15 years in various capacities with the Aluminum Co. of America, including two years as factory superintendent of the Aluminuin Index Co. In 1942, he joined the Worcester Pressed Steel Co. as assistant to the general manager. In 1946 he was made general superintendent, and soon thereafter was appointed to the board of directors. Later he was promoted to factory manager, which position he held until recently. Mr. Gulliksen is known in metalworking circles for his accomplishments in deep drawing and stamping of various metals, as well as for his work on the deep drawing of titanium.

Matt Conley, sales engineer for the Timken Roller Bearing Co., has been appointed district manager for the company's steel and tube division in Milwaukee. A graduate of the University of Pittsburgh, Mr. Conley started with Timken in 1948, working first in the metallurgical department and then in sales.

Harold T. Clark has been appointed director of research of Jones & Laughlin Steel Corp., Pittsburgh. Dr. Clark was employed by the Corporation as a research physicist in 1936, advancing from this position to research supervisor, assistant manager of research and development, director of metallurgical research, and in 1953 to assistant director of research, holding this position until his recent appointment. Prior to joining J & L, Dr. Clark taught at the American University in Cairo, at Lafayette College and at Purdue University, from which school he was awarded his Ph. D. in physics in 1936.

Reynolds
ALUMINUM REPORTER

★ ★ ★ Sixteenth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

ALUMINUM IMPROVED AS ELECTRICAL CONDUCTOR

Aluminum Screw Machine Skate Part Has Strength Without Weight

The skate toe stop shown below is made by Ware Brothers Division of Chicago Roller Skate Company. Reynolds 2011-T3 aluminum screw machine stock was selected for the part because it offers ample strength and mass yet is light in weight. This manufacturer of quality skates also uses a forged aluminum foot plate for the same strength to weight advantage.

Job for job, aluminum alloys machine at greater speeds and feeds, thus stepping up production. Unit costs for material, handling and shipping step down because of aluminum's light weight with strength.

For help on alloy selection and prompt delivery on aluminum screw machine stock call your Reynolds Office or Distributor listed under "Aluminum" in your classified telephone directory. Write on business letterhead for your free copy of the 124-page handbook, "Machining Aluminum Alloys." Address Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

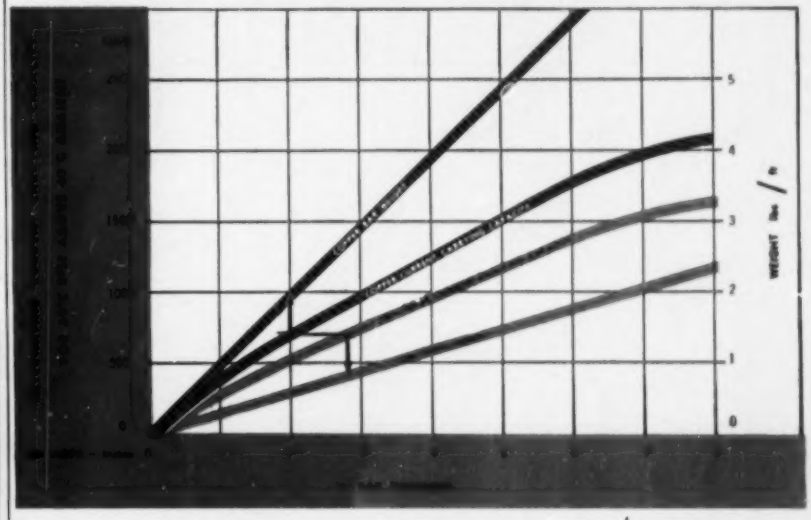
Aluminum Industry Adopts New Alloy Designation System

The Aluminum Association has developed a new system of wrought aluminum alloy designations to supplant various systems previously used. The new system which overcomes inadequacies of the old systems became effective on October first.

To speed transition from the old to the new standard designations the Reynolds Metals Company is offering a simplified conversion chart. Two sizes of the chart are available, one 17″ x 22″ is read easily when wall hung, the other is 8½″ x 11″ for use at desk or drawing board. Both old to new and new to old conversions are shown.

Write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky for your free copy of either size chart.

Reynolds Aluminum Development Increases Bus Conductor Strength; Maintains High Conductivity



A new Reynolds development, especially for bus conductor applications, provides greater strength with very little effect on electrical conductivity. An example from the chart above shows why this new material is just what the electrical industry ordered. A current load of 700 amperes requires a copper bar 2″ x ¼″ weighing just under 2 pounds per foot; new RABC (Reynolds Aluminum Bus Conductor) carries the same load with a 2.8″ x ¼″ bar weighing only 4/5 pound per foot. The result is a 60% saving in weight.

New Flexibility in Sizes and Shapes

In addition to providing greater strength advantages RABC is available in an unlimited range of sizes and shapes that permit designing to the minimum amount of metal needed for the current carrying job. It is no longer necessary to specify oversize conductors because of intermediate size limitations. The result is a material cost as low as or lower than for any previous aluminum bus conductor.

Many Cost Advantages

All of the basic advantages of aluminum bus conductor, of course, still hold true. More conductivity per dollar. Long range availability. Excellent resistance to corrosion. And, lighter weight which permits faster, easier handling and saves on installation time and labor costs.

ALUMINUM vs. COPPER BUS CONDUCTOR MATERIALS

PROPERTIES	COPPER	ALUMINUM EC-H17	ALUMINUM RABC
Tensile Strength (psi)	33,000 to 37,500	17,000	29,000*
Yield Strength (psi)	Not Specified	15,000	25,000*
Electrical Conductivity % IACS	98%	61%	55%*
Current Carrying Capacity†	100%	82%	79%
Resistivity @ 20°C (microhms, sq in./ft)	8.31	13.36	14.82
Modulus of Elasticity (lb/in.²)	16 x 10⁶	10 x 10⁶	10 x 10⁶
Density (lb/in.³)	.322	.09765	.09765
Temp. Coeff. of Resistance (% per °C @ 20°C)	.393	.403	.360

*Guaranteed minimum. †For given temperature rise and same cross section

Send for new descriptive literature on Reynolds Aluminum Bus Conductor and an index of other Reynolds Literature. Write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Kentucky.

300,000 Volts Plus Is Normal Load for Big Reynolds ACSR

Reynolds Metals Company recently fabricated a special order of Aluminum Cable Steel Reinforced (ACSR) as large as any cable yet made for overhead service in this country. This cable has an outside diameter of 1.76 inches and will be used in a 300,000 volt power system. This is a dramatic example of the advantages resulting from the light weight and electrical conductivity of Reynolds Aluminum.

Printed in U.S.A.

(Continued From Preceding Page)

Fluted Aluminum Tubing Ideal for Decorative Applications

Exceptionally beautiful effects in the construction of furniture and architectural decoration are being obtained through the use of tubular, fluted extrusions of 6063-T6 Reynolds Aluminum. They can also be used in making outdoor clothes driers and poles, umbrella and vacuum cleaner handles, display racks, clothes trees, ladder rungs and many other useful items. Ladder rungs of this material, for example, have a safer, non-slipping surface.

The new fluted aluminum tubing has an ultimate strength of 32,000 psi, a yield of 25,000 psi and 8% elongation. Data on standard sizes are given below.

Standard Tube Sizes*	Nominal Weight lb/100 ft	Minimum Inside Bend Radii	
		Machine Bending With Mandrel	Machine Bending Without Mandrel
¾" x .050" Wall	12.7	1 15/16"	1 5/8"
⅞" x .050" Wall	13.7	2 1/16"	2 3/16"
1" x .050" Wall	16.0	3 1/16"	2 13/16"
1" x .0625" Wall	20.0	2 3/16"	2 1/16"

*Other sizes available on special inquiry

Smooth surface drawn aluminum furniture tubing for other than fluted finishes, of course, continues to be available in 6063-T831 and 6063-T832 alloys and tempers, in ¾", ⅞" and 1" sizes, with .049" through .065" wall thicknesses. For more complete information write Reynolds Metals Company, 2576 South Third St., Louisville 1, Kentucky.

Reynolds New Master Alloy Aluminum Pigs Cut Foundry Costs

A new concept of reduction pot practices has resulted in the production of two new master alloy aluminum pigs at regular pig prices.

Both new pigs, designated as 2364 and 2393, have been added to the full line offered by the Reynolds Metals Company. Their use in foundries provides improved production control and fewer rejected castings.

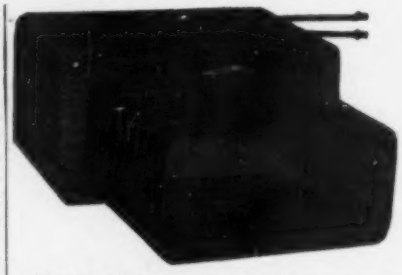
Available in the 50 pound size, these new master alloy pigs provide more uniform analysis through simple blending with secondary metals to control undesirable impurities.

Chemical analysis of 2364 alloy pig is silicon 6%, copper 4%, nominal iron and balance aluminum. 2393 alloy pig has a chemical analysis of silicon 9%, copper 3½%, iron ¾%, balance aluminum. Complete information on these and the family of aluminum pig and ingot products by Reynolds is available from the Reynolds office or Pig and Ingot Distributor listed under "Aluminum" in your classified telephone directory. Or write direct.

Printed in U.S.A.

Roll Bonded Aluminum Sheet Now Produced by Reynolds for Refrigeration Industry

Reynolds roll bonded aluminum sheet is two sheets of aluminum metallurgically bonded together. It is an ideal material for refrigerator evaporators, freezer liners and freezer cold plates. In fact, it should be an economical, efficient and practical replacement for all applications involving heat exchanging where tubing fastened to sheet has been used in the past.



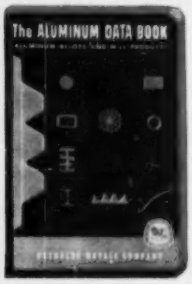
Metal ordinarily used for tubing, accumulators and receivers is eliminated. The passageways are inside the sheet. There are no tubes to bend. Welding is minimized. There is no brazing and therefore no flux contamination. Many connecting and assembly operations are eliminated. There is no problem of lost conductivity. Cleaning time and expense are reduced because there are no deep crevices where tubing meets sheet.

Tubing contours smoothly into the sheet. Expansion, radius and bending problems inherent with tubing are eliminated. You can route refrigerants wherever they are needed. Passageways may be flat, oval or round. They can be smaller and can be placed closer together. Additional length adds nothing to the cost. Reynolds roll bonding is strong and compact. Passageways themselves act as stiffening ribs and contribute to the overall sturdiness of the unit.

For more details on Reynolds roll bonded aluminum sheet or for Reynolds engineering assistance on fabricated parts for your particular products, regardless of your industry, contact the Reynolds office listed under "Aluminum" in your classified telephone directory. Write for your free copy of the 20-page brochure, "Aluminum Appliance Parts" and the 24-page "Catalog of Facilities" to Reynolds Aluminum Fabricating Service, 2065 South Ninth Street, Louisville 1, Kentucky.

New Edition of "Aluminum Data" Offers Valuable Information to Aluminum Users

Reynolds Metals Company has just released the 1954 edition of the "Aluminum Data Book". It contains 220 pages of detailed information on the properties and characteristics of aluminum and is considered the most complete and up-to-date technical information on aluminum now available.



Text and tabular information on physical, chemical and mechanical properties of aluminum as well as data on tolerance, weight, fabricating characteristics, etc. have been expanded.

Entirely new information is presented on radioactive isotopes of aluminum, thermal neutron absorption cross sections for various metals, as well as the elements found in commercial aluminum alloys.

Other new material includes a section on "Availability" showing manufacturing limits on standard aluminum mill products and giving details on aluminum powders, pastes and chemicals. A section is devoted to the new alloy designation system just adopted by The Aluminum Association. New and old system equivalent tables are shown.

Single copies of the book are available to engineers, designers, technical men, instructors and executives without charge when request is made on a business letterhead. Address requests to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Reynolds Begins $2,585,000 Expansion of Sheffield, Alabama Sheet Mill

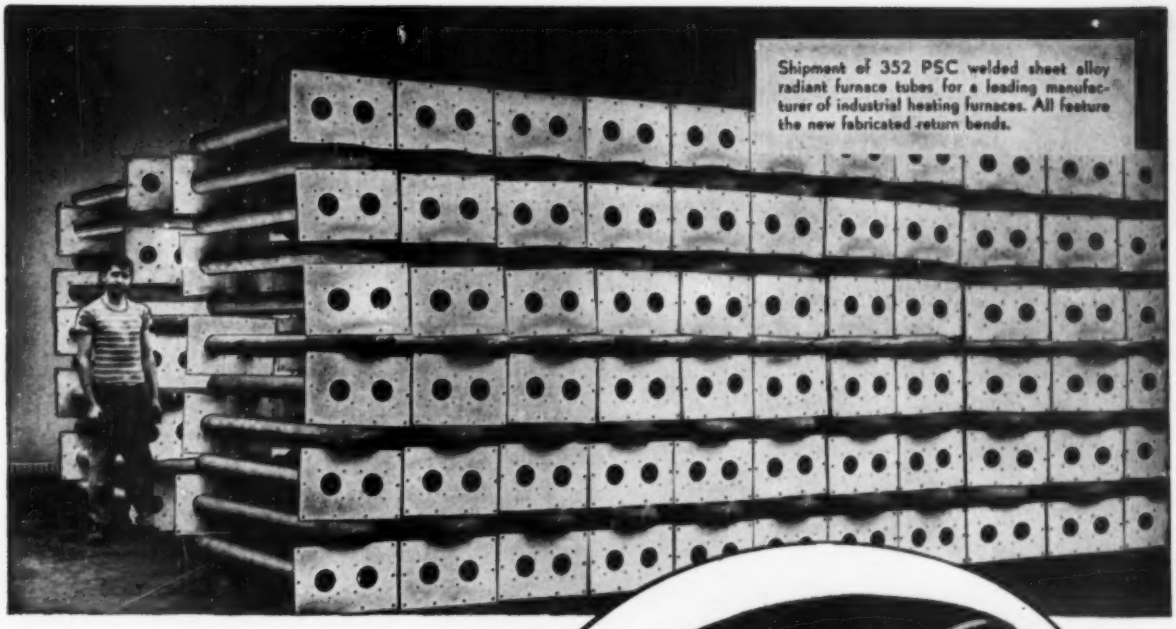
New melting equipment capable of producing about 90,000,000 pounds of aluminum annually is being installed as the first step in a broad expansion program planned for Reynolds sheet mill in Sheffield, Alabama. This will permit Reynolds to give better delivery to the ever-expanding market for aluminum sheet. Additional annealing facilities consisting of four new furnaces, each with a capacity for 120,000 pounds of aluminum coils are also being added to the plant.

A number of new buildings will be required to house the new melting and annealing facilities.

Fabricators Benefit from Reynolds Design Seal Program

More and more manufacturers are participating in the "Designed in Reynolds Aluminum" Seal program. Applied to the manufacturers' products it tells a stronger quality story at point-of-sale. Reynolds national magazine advertising and outstanding "Mister Peepers" TV show are benefiting Seal program participants.

For details on how your company can qualify for the Seal, write Reynolds Metals Company, 2576 So. Third St., Louisville 1, Ky.



Shipment of 352 PSC welded sheet alloy radiant furnace tubes for a leading manufacturer of industrial heating furnaces. All feature the new fabricated return bends.

PSC's *New* FABRICATED Return Bends

make radiant furnace tubes last longer

Here are three reasons why sheet alloy radiant furnace tubes equipped with the new PSC fabricated return bends are serving better: (1) Uniform wall thickness, and smoothness of interior result in uniform flow of gases; less cracking and burning out at the bends. (2) Light-wall construction saves heat-up time and fuel. (3) From 33 to 50% lighter than cast tubes: lower initial cost; lower freight cost (important for export); easier handling.

PSC precision-assembled tubes are standard on many models of radiant furnaces. Also a complete line of heat-treating containers and fixtures, of weight-saving sheet alloys of any type. Send blue prints or write as to your needs.

Send for CATALOG 52

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆

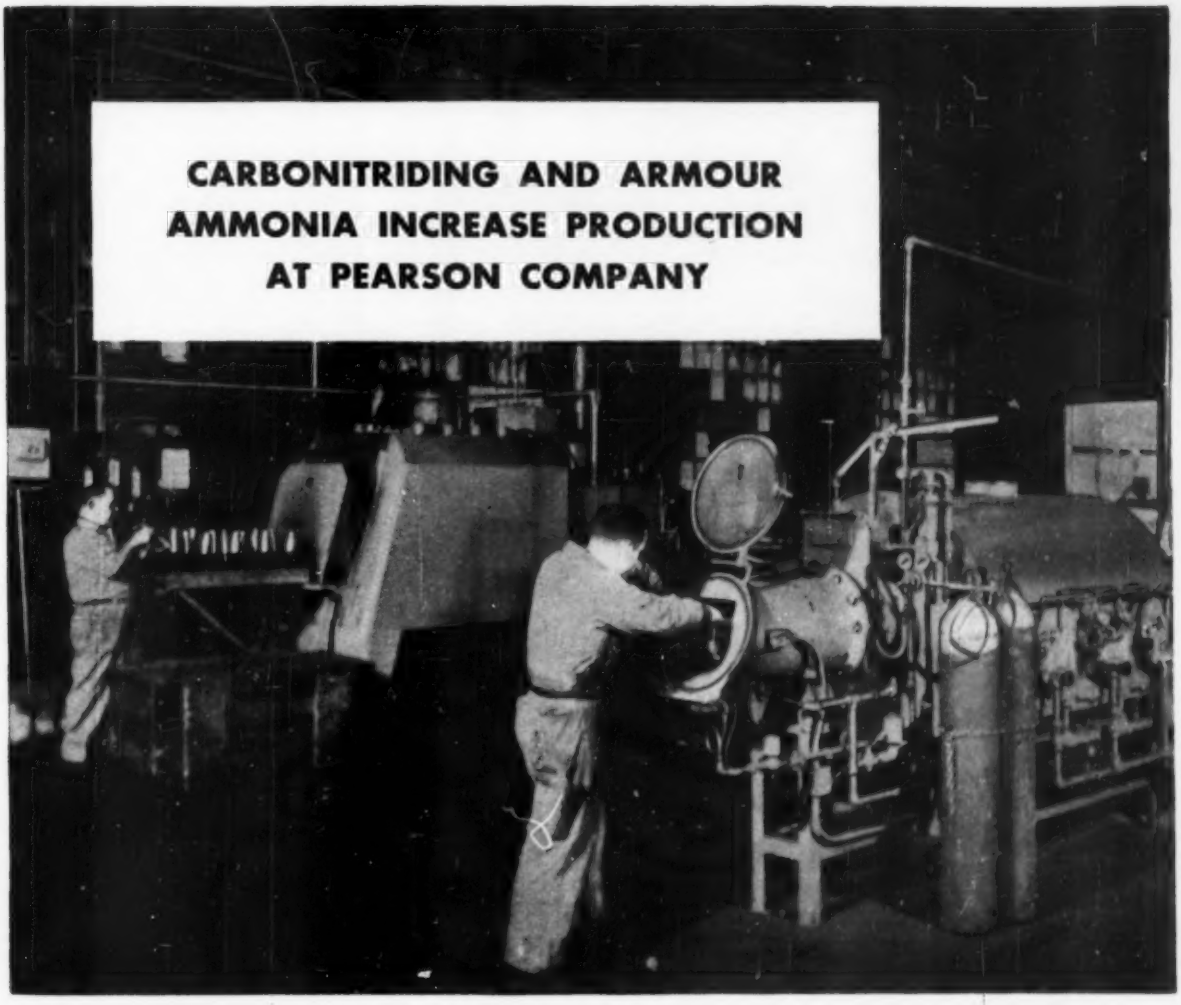
Personals . . .

Henry J. Fisher has been appointed a research associate on the staff at the General Electric Research Laboratory, Schenectady, N. Y. Dr. Fisher, a metallurgist specializing in foundry processes and development, is a native of Canada who has studied at Queen's University in Kingston, Ont., at the University of Birmingham in England, and at Yale University, where he received his doctor's degree in engineering. Since 1945, he has been a scientist on the staff of the Department of Mines and Technical Surveys, Ottawa, Canada.

Edward A. Loria was recently appointed staff metallurgist for Crucible Steel Co. of America and assigned to the central metallurgical office in Pittsburgh. His principal efforts will be in the field of stainless and heat resisting materials for aircraft, automotive and power generating applications. He was formerly associated with the research and development department of the Carborundum Co., Niagara Falls, N. Y. Mr. Loria's previous experience also includes service as senior fellow in metallurgy at the Mellon Institute of Industrial Research and as assistant metallurgist in the research and development laboratory of the U.S. Steel Corp. Mr. Loria was graduated from Carnegie Institute of Technology with B.S. and M.S. degrees in metallurgical engineering. He has also completed graduate courses in metallurgical engineering and physical metallurgy at the University of Pittsburgh and Massachusetts Institute of Technology. He is the author of more than 30 technical papers on the physical and process metallurgy of iron and steel.

Robert Lee Weidman has been appointed technical sales representative for the Cooper Alloy Foundry Co., Hillside, N.J. He is a graduate of Pennsylvania State University with a B.S. degree, and prior to his present appointment was eastern sales engineer for Michiana Products Corp., Michigan City, Ind.

W. P. Woodside, Jr., associated with Park Chemical Co., Detroit, for the past 18 years as sales representative in the Cleveland territory, has now been elected president of the company.



CARBONITRIDING AND ARMOUR AMMONIA INCREASE PRODUCTION AT PEARSON COMPANY

New processes prove more efficient, safer for metal treating

Those carbonitriding and brazing furnaces above mean greater production and safety at the Pearson Industrial Steel Treating Company in Chicago. And Pearson specifies Armour's pure, dry ammonia and dependable service for their carbonitriding.

All through the metal treating field, plants are using every improved process they can to provide their clients with better work. Since many of these new processes require ammonia, more and more companies like Pearson are calling on Armour ammonia and service for best results.

Carbonitriding has reduced costs and increased safety in many plants. And Armour men were there in many cases to give advice and help on installations. Those men in Armour's Technical Service Department are equipped and ready to help you in your installation.

Since 1947 Armour has sponsored a fellowship at the Massachusetts Institute of Technology for the study of carbonitriding and other modern metal treating processes. That knowledge is basic research, and available to you.

Save money on our tank truck delivery service available in most areas

The booklets offered below will show you how to put this knowledge to work in your plant. Write today for free copies. If your ammonia problem is unusual or pressing, write us giving full details of your requirements.

Clip and mail this today!

- ☐ "Applications of Dissociated Ammonia"
- ☐ "Ammonia Installations for Metal Treating"
- ☐ "The Nitriding Process"
- ☐ "Carbonitriding"

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Firm_____

Address_____

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P12

ARMOUR *Ammonia Division*

Armour and Company • 1355 West 31st Street • Chicago 9, Ill.

Personals . . .

Clarence G. Bieber and **George R. Pease** have been appointed, respectively, head of the special alloys section and head of the welding section at the Bayonne (N.J.) Research Laboratory of the International Nickel Co., Inc. Mr. Bieber, who received his technical education at the University of Wisconsin, joined the staff of Inco's Huntington, W.Va., works in March 1924, and in 1939 he became works metallurgist, the position he held until his present appointment. His studies in melting, deoxidizing and refining of nickel alloys have resulted in the issuance of 18 United States and many foreign patents. Mr. Pease is a master of science graduate of the University of Massachusetts. He was a chemist with the Springfield Armory of the U. S. Army Ordnance Department from 1939 until 1945, when he joined the staff of the Bayonne Laboratory. His work has centered on the development of new welding electrodes and has resulted in a number of patents and technical papers.

Robert B. Heppenstall, Jr. has been named general manager of the Bridgeport, Conn., plant of Heppenstall Co. Starting with the company on a part-time basis in 1945, he has been employed full time since 1950, and has served as manager of market research since 1953. He represents the fourth generation of Heppenstalls associated with the company, founded by his great-grandfather in 1889. His father, Robert B. Heppenstall, Sr., is president.

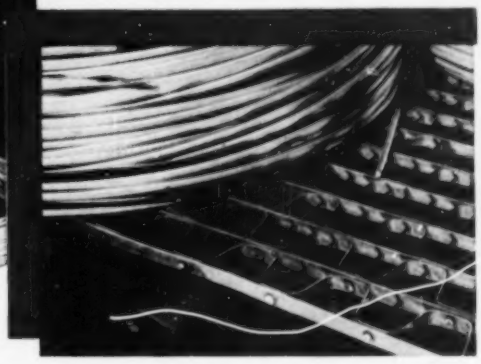
M. A. Burello, formerly with the market research and sales promotion department of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., has joined the product planning group of Carboloy Dept. of General Electric Co. in Detroit. Mr. Burello, who participated in product research on titanium at du Pont, and on ferro-alloys prior to that when associated with Vanadium Corp. of America in Pittsburgh, holds a B.S. in metallurgical engineering from Queens University, Kingston, Ont.

Edward F. Mooney, formerly representative for Armour & Co., Boston, has been appointed New England sales representative for C. I. Hayes, Inc., Cranston, R.I.

ROLOCK

FABRICATED ALLOYS

ONE-PIECE "KING SIZE" SERPENTINE FURNACE GRID



NOW SERVES KAISER ALUMINUM

This, we believe, is the largest single piece grid of its type ever produced . . . and three of them are now in use at the Newark, Ohio Works of the Kaiser Aluminum & Chemical Corporation.

Despite the extreme length of the carrier (25 feet), there is freedom from warpage, due to the "Serpentine" and tie-rod design as shown in the insert photo above. Type 304 stainless steel strip with rolled edges prevents marring the coiled aluminum rod through annealing at 900° to 950°F. and water-spray quench at 60° to 80°F.

The first Rolock 8 ft. serpentine grids performance-wise were a big improvement over previous carriers, but the present 25 ft. "King Size" gives complete stability on the conveyor through the spray quench cycle and reduces multiple handling costs significantly. Grids are 6 ft. wide each, providing 150 sq. ft. of usable surface.

As in this instance, Rolock engineers will gladly cooperate with yours in designing engineered-to-the-job equipment for heat treating and finishing processes. We've solved many tough jobs . . . and are looking for more. Ask for Catalog B-8 (Heat Treating) or B-9 (Corrosion Resistant).

Offices in: ANDERSON, IND., CHICAGO, CLEVELAND, DETROIT, HOUSTON, LOS ANGELES, MINNEAPOLIS, PHILADELPHIA, PITTSBURGH, ST. LOUIS

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB ENGINEERED for better work Easier Operation, Lower Cost

10RL54A

Personals . . .

Robert L. Reed was recently appointed district manager of the Pittsburgh office of Electro Metallurgical Co., a division of Union Carbide and Carbon Corp. Mr. Reed, a graduate of Ohio State University, joined the company as a sales engineer in 1946 after completing some confidential metallurgical research for the War Department. He served in Electromet's Chicago and Detroit offices before going to Pittsburgh in 1953.

A. C. Wickman, former president of A. C. Wickman, Ltd., Coventry, England, and recently chairman of A. C. Wickman, Canada, Ltd., has retired as a director of Firth Sterling, Inc., Pittsburgh.

George M. Thomas has been named associate metallurgist in the sintered metals laboratory of International Business Machines Corp., Endicott, N.Y. Mr. Thomas began his association with IBM in January 1954, when he was employed as a technical engineer in the metallurgical laboratory, the position he held at the time of his recent appointment. He graduated from the Colorado School of Mines in 1944 with a B.S. degree in metallurgy, and received his M.S. from Stevens Institute of Technology in 1950.

Alfred Taboada, formerly with Curtis-Wright Aircraft Corp., Wood Ridge, N.J., and **Clarence H. Wodtke**, formerly with Northern Ordnance, Inc., Fridley, Minn., have been appointed to the staff of one of the Atomic Energy Installations at Oak Ridge, Tenn., operated by Carbide and Carbon Chemicals Co., a division of Union Carbide and Carbon Corp.

Milton Stern has been appointed to the staff of the metals research laboratories of Electro Metallurgical Co., a division of Union Carbide and Carbon Corp., Niagara Falls, N.Y. Dr. Stern has been assigned to the chemical research group as a senior research assistant. He received his B.S. degree in chemical engineering from Northeastern University in 1949, and the M.S. degree in metallurgy and the D.S. degree in physical metallurgy from Massachusetts Institute of Technology in 1952.

Why Pickle the Equipment Too?

ALLOY TRAYS SAVE $1600 A YEAR— Pickling trays made of HASTELLOY alloy C have saved a company $1600 a year. The trays are immersed in hot 20 per cent hydrochloric acid and then into a solution of one per cent phosphoric acid with ferric salts at 205 deg. F. This treatment is used to produce a porous surface on metal parts. HASTELLOY alloy trays last two years. Other trays lasted only two months.

SIX YEARS IN HOT HCl—This HASTELLOY alloy B pickling tank has already outlasted other materials by four times. It is expected to be good for many years to come. The tank holds hot 15 per cent hydrochloric acid used to remove grease and lacquer from cast iron parts.

VAT PAYS FOR ITSELF—Here's a HASTELLOY alloy C vat that has already paid for itself and is still going strong. It is used to pickle copper parts in a mixture of 30 per cent nitric acid and 60 per cent sulphuric acid at 180 to 200 deg. F. Crocks previously used had to be replaced on an average of every six months.

•

HASTELLOY *alloys can solve some of your corrosion problems, too. For further information, contact the nearest Haynes Stellite Company office listed below.*

"Hastelloy" is a registered trade-mark of Union Carbide and Carbon Corporation.

HASTELLOY *alloys*

Trade-Mark

Nickel-base, corrosion-resistant alloys available as sheet, plate, bar stock, welding rod, welded tubing and pipe, cast pipe and fittings, sand and precision-investment castings.

Haynes Stellite Company
A Division of
Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago — Cleveland — Detroit — Houston
Los Angeles — New York — San Francisco — Tulsa

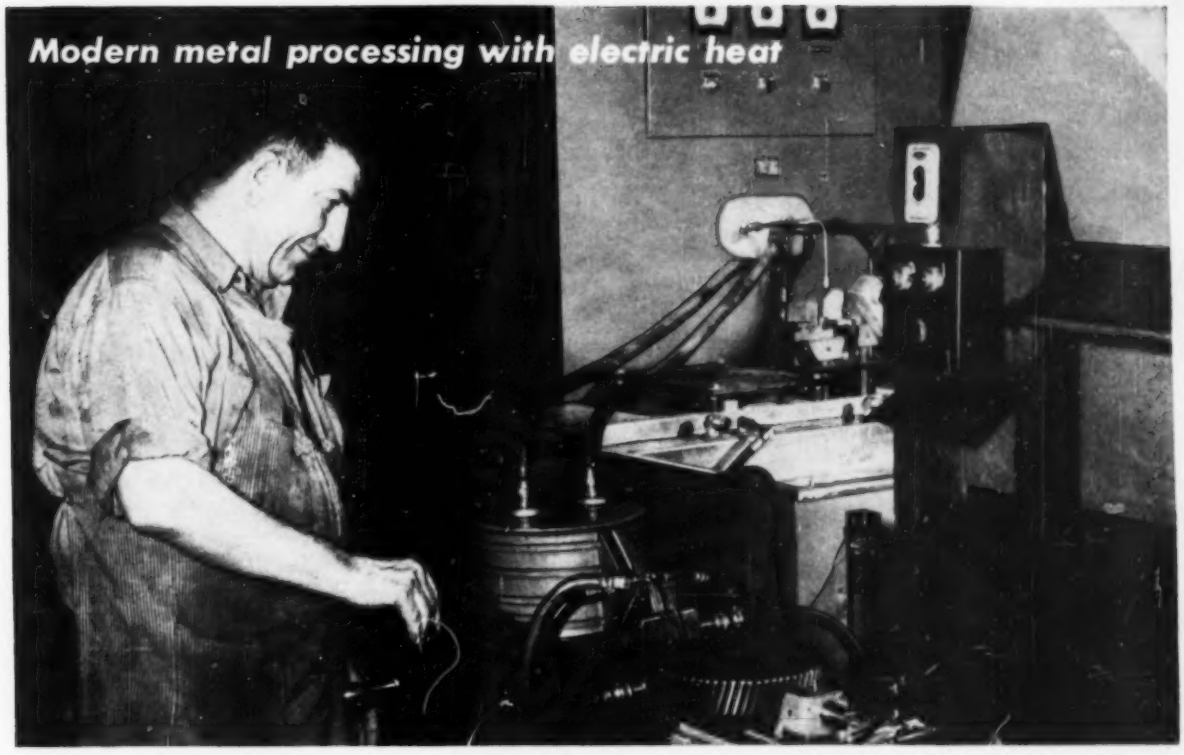
Personals . . .

Don M. Johnson, chief metallurgist in the Cleveland Works Div. of Jones & Laughlin Steel Corp. since 1950, has been appointed to a position on the Corporation's metallurgical contact staff, and will handle customer service contacts, primarily on sheet products, out of the Cincinnati district sales office. Mr. Johnson is a graduate of the Colorado School of Mines, with the degree of metallurgical engineer, and has served in the Cleveland metallurgical department since 1933. Appointed to be assistant chief metallurgist is **Jack W. Culver**, who has been plant metallurgist and chief inspector at Jones & Laughlin's Electricweld Tube Div. in Oil City, Pa., since 1951. A graduate of Carnegie Institute of Technology, Mr. Culver has been associated with J & L since 1939.

Charles H. Schwerin has been appointed manager of the industrial furnace division of the Gas Machinery Co., Cleveland. With 19 years' experience in the industrial furnace field, Mr. Schwerin's previous posision was manager of sales and sales engineering for the George J. Hagan Co., Pittsburgh. A graduate of Carnegie Institute of Technology, he is one of the pioneers in the automation of the heat treatment of steel, iron and aluminum, and also initiated the use of automatic rotary-hearth furnaces for heating slabs for plate mills and blooms for rolling mills.

Bruce Wise, a graduate of Case Institute of Technology, has completed his sales training program and has been assigned to the Los Angeles office of the Timken Roller Bearing Co. **John Szuhay**, also a graduate of Case Institute of Technology, has completed the steel sales training program and has been assigned to the Cleveland office of the Timken Company as a sales engineer.

Vance H. McNeilly, formerly with Purdue University, division of engineering sciences, as instructor and supervisor of ordnance research project, having received his Ph.D. in June '54, is now an engineer in the development engineering division of the engineering department, mechanical research section, mechanical development laboratory, E. I. du Pont de Nemours & Co., Wilmington, Del.



TOOTH-AT-A-TIME HARDENING USING G-E INDUCTION HEATER PRODUCES HIGH-QUALITY GEARS IN MANY SIZES.

Fifteen-inch gears quality hardened with 20-kw G-E induction heater

New Britain Machine eliminates grinding and copper plating costs

By switching from furnace to induction hardening with General Electric induction heaters, New Britain Machine Co., New Britain, Conn., improved their gears with a minimum investment in new equipment.

Equipment costs were reduced by installing a fixture that makes it possible to harden a tooth at a time. In this way, New Britain can heat-treat gears up to 15 inches in diameter with only a *20-kw* G-E heater.

Hardening is confined to the tooth surfaces, where the wear is greatest, leaving the core shock resistant. Formerly, New Britain either carburized and hardened the gears completely—a process which caused distortion and required expensive grinding—or they had to copper plate the gears for selective hardening.

For information on how you can cut costs and improve your products using G-E induction heat, contact your nearest G-E Apparatus Sales Office. And write for the new modern-metal-processing bulletins—Forging with Induction Heat, GEA-5983, and Furnace and Induction Brazing, GEA-5889. Address: Section 720-137, General Electric Co., Schenectady 5, N. Y.

GENERAL ELECTRIC

WITH ACCURATE INDUCTION HEAT, hardening can be limited to areas where pressure and wear are greatest. Core remains shock resistant.

Personals . . .

Anton F. Mohrnheim, registered professional engineer of the Province of Ontario and until recently research fellow at the Ontario Research Foundation, Toronto, is engaged in establishing a new production and research laboratory for semifinished products of laminated precious and nonferrous metals at Leach & Garner Co., Attleboro, Mass.

Franz R. Brotzen has been appointed assistant professor of mechanical engineering at Rice Institute, Houston, Tex.

Lloyd E. Rautiola is on a military leave of absence from the magnesium division, Dow Chemical Co., Midland, Mich., where he was employed as a metallurgist.

William O. Wood has joined Vanadium-Alloys Steel Co. and will work out of the St. Louis, Mo., office as a sales engineer. Mr. Wood was formerly with the Lindberg Steel Treating Co., Chicago.

Donald E. Matthieu has resigned his position as chief metallurgist for the Alabama Pipe Co., Anniston, Ala., to become district sales manager for Kerchner, Marshall and Co., Richmond, Va.

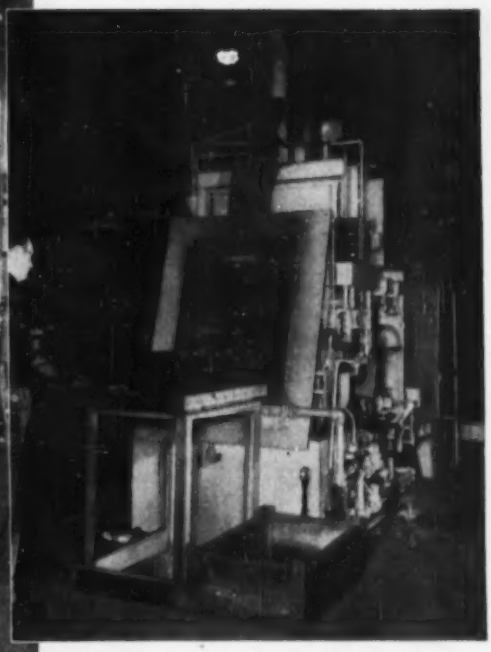
Richard E. Fronko is employed as a metallurgist in the mill metallurgical department, Sanderson-Halcomb Works, Crucible Steel Co. of America, Syracuse, N.Y.

James T. Parker, formerly sales engineer and director of machinability research for the La Salle Steel Co. in Hammond, Ind., is now sales engineer for the Southern California Aluminum Treating Co.

Thomas E. Tietz has received his doctorate in physical metallurgy from the University of California and is now employed as associate physical metallurgist at Stanford Research Institute, Stanford, Calif.

Robert J. DeVoe is now enrolled in the General Electric Co.'s manufacturing training program, and is at present assigned to the major appliance division, Louisville, Ky.

Leon D. Michelove has joined the staff at Battelle Memorial Institute, Columbus, Ohio, as a research engineer.



Left: New England Metallurgical Corporation installed first Lindberg Carbo-nitriding Furnace at Worcester plant.

Above: Six months later New England Metallurgical installed second Carbo-nitriding Furnace at Boston pant.

One *LINDBERG* Carbo-nitriding Furnace merited another at New England Metallurgical Corporation

"Our first Lindberg Carbo-nitriding furnace in January . . our second one installed just 6 months later!" Yes, that's what happened in the plants of New England Metallurgical Corp., Boston, Mass., for more than 28 years well known commercial heat treaters.

The first unit, a gas fired, radiant tube, carbo-nitriding furnace went to the company's Worcester plant known as Greenman Steel Treating Company.

Six months later a second Lindberg Carbo-nitriding furnace was installed in the Boston plant of New England Metallurgical Corporation . . and this team of versatile "work horses" have been continually turning out production . . 24 hours a day.

Mr. Lloyd Field, Vice-President and General Manager of the Worcester Division, has this to say about the Lindberg Carbo-nitriding Furnaces: "We selected Lindberg Carbo-nitriding Equipment for the usual reasons . . cost cutting . . uniform, quality work . . high, dependable production. But more than that . . as you know, variety seems to be the spice of a commercial heat treater's life, and because of the versatility of the Lindberg Carbo-nitriders, which are actually five furnaces in one, they are without doubt our busiest and most valuable pieces of equipment.

"When customers send in work for carbo-nitriding, carburizing, neutral hardening, annealing, or carbon restoration, a hue and cry goes up to check for room on the heavy schedules of the Lindberg Carbo-nitriding Furnaces."

Lindberg Carbo-nitriding Furnaces can do a job for you, too. Ask for bulletin No. 241.

LINDBERG FURNACES

Lindberg Engineering Company • 2448 Hubbard Street • Chicago 12, Illinois

Personals . . .

Edward T. Stephenson, after three years' service in the U. S. Navy as an engineering duty officer, has entered graduate school at Massachusetts Institute of Technology to study for a M.S. in metallurgy while working as a part-time research assistant.

Herman A. Johansen has resigned his position with Albany Station, U. S. Bureau of Mines, to accept a research fellowship at the University of Oregon, department of chemistry.

F. D. Brookshire, formerly chief metallurgist with General Motors Overseas Operation Div. in Melbourne, Australia, is now a metallurgical engineer with General Motors Process Development Section, Detroit.

Niculas Boboc, Jr. is now a field service engineer in the metalworking department, Western Div., E. F. Houghton & Co.

Krishan K. Tangri, who received the degree of B.Sc. from Punjab University in 1944 ,B.Sc. in metallurgy from Banares Hindu University in '48, M.S. in '52 and Ph.D. in 1954 from the Missouri School of Mines and Metallurgy, is now research associate in the department of metallurgy at Pennsylvania State University.

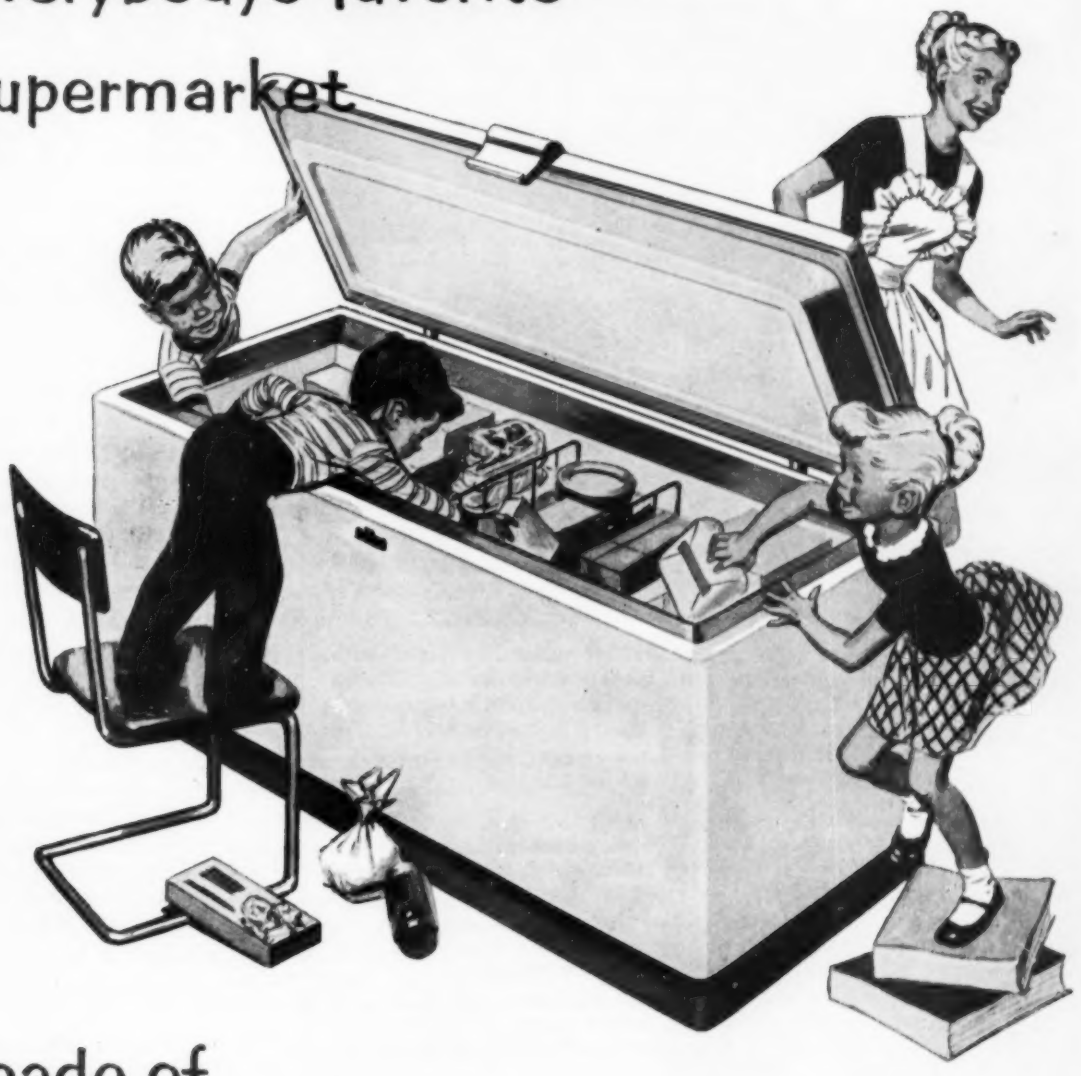
J. E. Atherton has resigned as associate metallurgist at Brookhaven National Laboratory to accept a position with the United States Radium Corp. in the Bloomsburg, Pa., plant.

Sumio Yukawa has accepted a position as metallurgist, material and process laboratory, large steam turbine-generator department, General Electric Co., Schenectady, N.Y.

Martin C. Parks has accepted a position as plant superintendent of Texas Aluminum Co., Rockwall, Tex.

William E. Litterer has resigned as superintendent of the heat treating department of Philadelphia Gear Works to take on new duties as plant manager of the Electric Steel Treating Co., Bordentown, N.J. Prior to joining Philadelphia Gear, Mr. Litterer founded and operated the present Ace Heat Treating Co., Elizabeth, N.J.

everybody's favorite supermarket



made of flat-rolled steel

Appliances as well as kitchen equipment like cabinets and sinks need a good *suit of armor*—made of flat-rolled steel—when they're put to the test of normal use.

If you use flat-rolled steel in your products, rely on a specialist—Great Lakes Steel. Our entire organization is devoted to the business of making more and better flat-rolled steel for every application. Many manufacturers have found we have some unique qualifications to help them improve products and reduce costs. We would like the opportunity to work with you on your problems.

Call on our 25 years of specialization in flat-rolled products. Our representative will be glad to discuss your particular needs at your request.

Great Lakes Steel

Ecorse, Detroit 29, Michigan

PRODUCER OF N-A-X HIGH-TENSILE STEEL

UNIT OF NATIONAL STEEL CORPORATION

SALES OFFICES IN CHICAGO, CLEVELAND, GRAND RAPIDS, INDIANAPOLIS, LANSING, NEW YORK AND PHILADELPHIA.

Personals . . .

Dave Preston, formerly supervisor of materials and processes, aircraft accessory turbine department, General Electric Co., Lynn, Mass., is now employed as development engineer in the alloy division of Great Lakes Steel Corp. in Detroit, a subsidiary of National Steel Corp.

James G. McGinnis has been made sales manager of Audubon Wire Cloth Corp., Philadelphia.

After 47 years with the company, **Howard S. Lewis** has retired as president of Parish Pressed Steel Co., Reading, Pa., a division of Dana Corp.

Harry R. Shuptrine, until recently employed by Parker Rust Proof Co., Detroit, has accepted a position as production engineer at Pacific Tube Co., Los Angeles.

John A. Switzer is now employed as manufacturing engineer with Aviation Gas Turbine Div., Westinghouse Electric Corp., Kansas City, Mo.

William H. Snair, formerly in the research and technical department, American Can Co., Chicago, has joined the metallurgical staff of Great Lakes Steel Corp., Ecorse, Mich., and is in the research development and quality control department.

D. F. Nisbet has been transferred by Shell Oil Co. from Wilmington, Calif., to Anacortes, Wash., where the company is building a new refinery. Mr. Nisbet was also promoted to senior engineer with the title of chief inspector.

John D. Fatheree, Jr., on a leave of absence from the Youngstown Sheet and Tube Co., is now on active duty as a second lieutenant in the U. S. Army.

R. J. McAllister is now employed as junior development engineer with Consolidated Mining and Smelting Co. of Canada, Rossland, British Columbia.

Sidney D. Tannenbaum has resigned as experimental metallurgist at General Motors Corp., Truck and Coach Div., Pontiac, Mich., and has accepted a position as metallurgist at Consolidated Vultee Aircraft Corp., Fort Worth, Tex.

SPECIAL JOB?

Get a special Chase alloy!

TELLURIUM COPPER

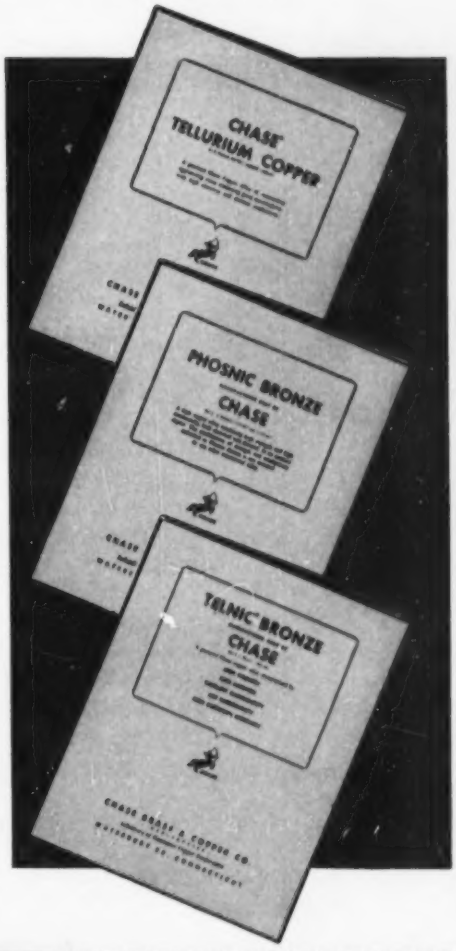
This alloy, developed by Chase, has excellent machinability *plus* high conductivity. Chase Tellurium Copper can be machined with tool speeds and settings similar to those used with Free-Cutting Brass, permitting high rates of production. But, unlike Free-Cutting Brass, Chase Tellurium Copper may be hot worked easily, and may be cold worked almost as extensively as pure copper. For Chase's free Tellurium Copper booklet, check the coupon below.

PHOSNIC® BRONZE

Chase Phosnic Bronze, an alloy made *only* by Chase, combines high strength and high conductivity to an amazing degree. This combination of high strength, high conductivity is *not matched by any other commercial alloy*. Chase Phosnic Bronze also has excellent workability, high corrosion resistance, and is available in tube, rod, and round or rolled flat wire. For Chase's free Phosnic Bronze booklet, check the coupon below.

TELNIC® BRONZE

By adding small, accurately proportioned amounts of tellurium, nickel and phosphorus to copper, Chase developed Telnic Bronze—a truly "all purpose" alloy. Chase Telnic Bronze has *excellent* machinability, hot and cold workability, high strength and conductivity, high fatigue strength and superior corrosion resistance. Chase Telnic Bronze is available in round or hexagonal rod. For Chase's free Telnic Bronze booklet, check the coupon below.



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The Nation's Headquarters for Brass & Copper (†sales office only)

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Boston	Dallas	Houston	Milwaukee	New York	Rochester†	Waterbury

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☐ PHOSNIC BRONZE ☐ TELNIC BRONZE

Name_____
Position_____
Firm_____
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City_____ State_____

Personals . . .

Jack C. Biltz is now quality control engineer for foundry operations in the Oil City (Pa.) Works of Worthington Corp.

Leroy E. Johnson is a sales engineer in the industrial furnace division of Sunbeam Corp., Chicago.

Dean N. Williams has resigned from the department of metallurgical research of Kaiser Aluminum and Chemical Corp., Spokane, Wash., to accept a position in the nonferrous physical metallurgy division at Battelle Memorial Institute, Columbus, Ohio.

Albert E. Katzer has accepted a position with Pioneer Central Div. of Bendix Aviation Corp., Davenport, Iowa, to direct a research and development program on metallic diaphragms and anterroids for aircraft instruments. Mr. Katzer was previously associated with AC Spark Plug Div. of General Motors Corp. as project engineer on fire control systems.

Frank Kiper, for ten years works manager at the Springfield, Ohio, plant of Ohio Steel Foundry Co., is now vice-president of Misco Corp., Chicago.

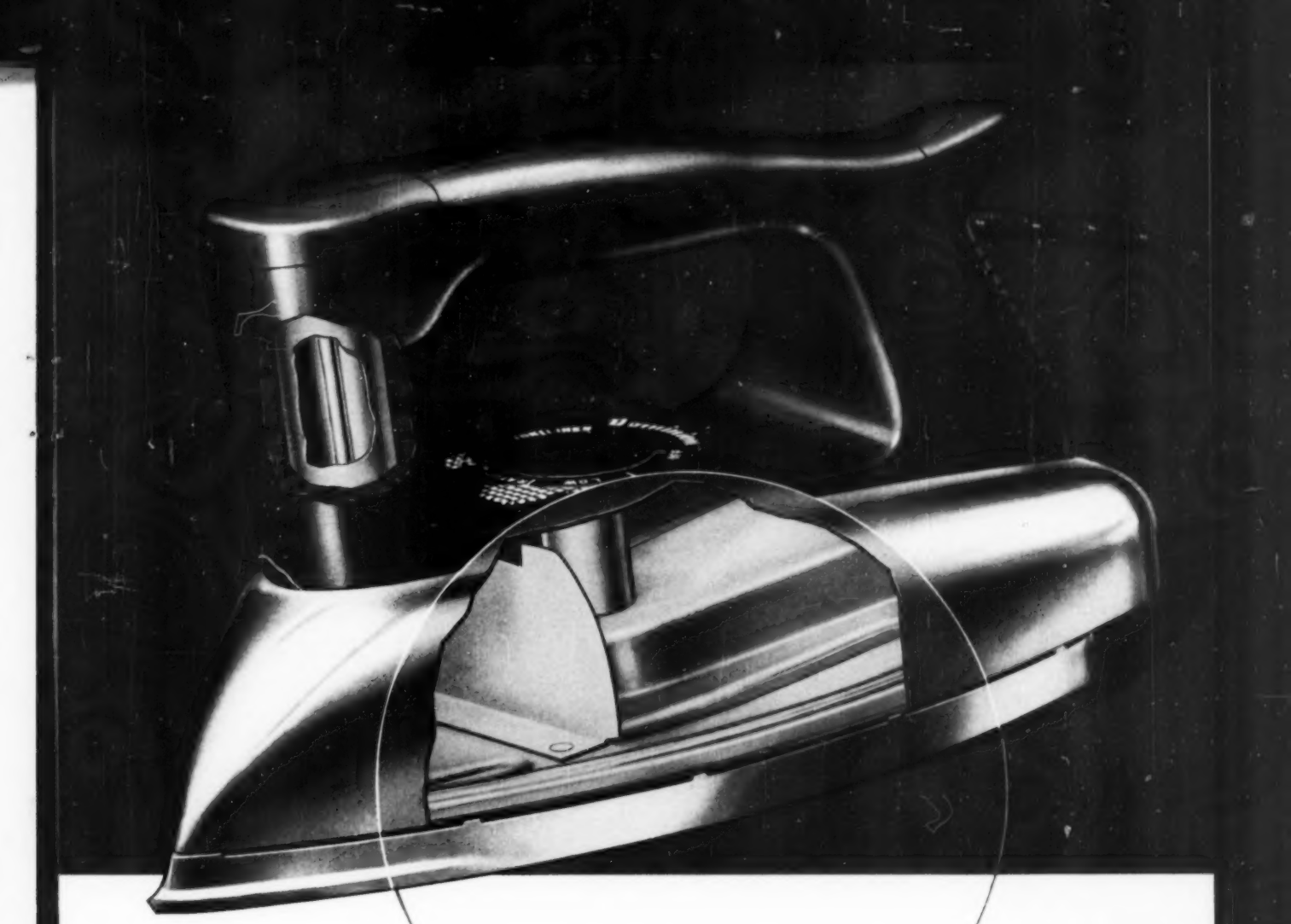
R. K. Waldoojel recently changed positions from welding engineer at Crosley-Bendix Div. of Avco Mfg. Corp., Richmond, Ind., to welding engineer at Stromberg-Carlson Co., Rochester, N.Y.

Edwin Elliott, Jr. is now employed as a metallurgist in the special projects section at the Solar Aircraft Co., Des Moines, Iowa.

Marvin Metzger has resigned from the scientific staff at Columbia University to accept an appointment as research assistant professor of physical metallurgy at the University of Illinois.

John R. Steele, formerly chief metallurgist of the Studebaker Co., Chicago Aircraft Engine Div., is now advisory engineer for Westinghouse Electric Corp., Aviation Gas Turbine Div., Kansas City, Mo. The new position entails the development and production of jet engines.

David F. Dickinson is now a member of the chemical engineering staff at the University of Tulsa.



Peek under this gleaming chromium plate

and see functional, durable, BRASS at work

In adding a combination steam-and-dry iron to its list of electrical appliances, The Dominion Electric Corp., Mansfield, Ohio, set its goals high. The iron had to be engineered, styled and priced so as to be readily salable in a highly competitive market.

1 Costs *must* be kept down – without sacrificing quality.

2 The iron *must* be light in weight (actually 3¼ lb.) and provide a long service life.

3 It *must* operate unfailingly – anywhere – on ordinary, undistilled tap water.

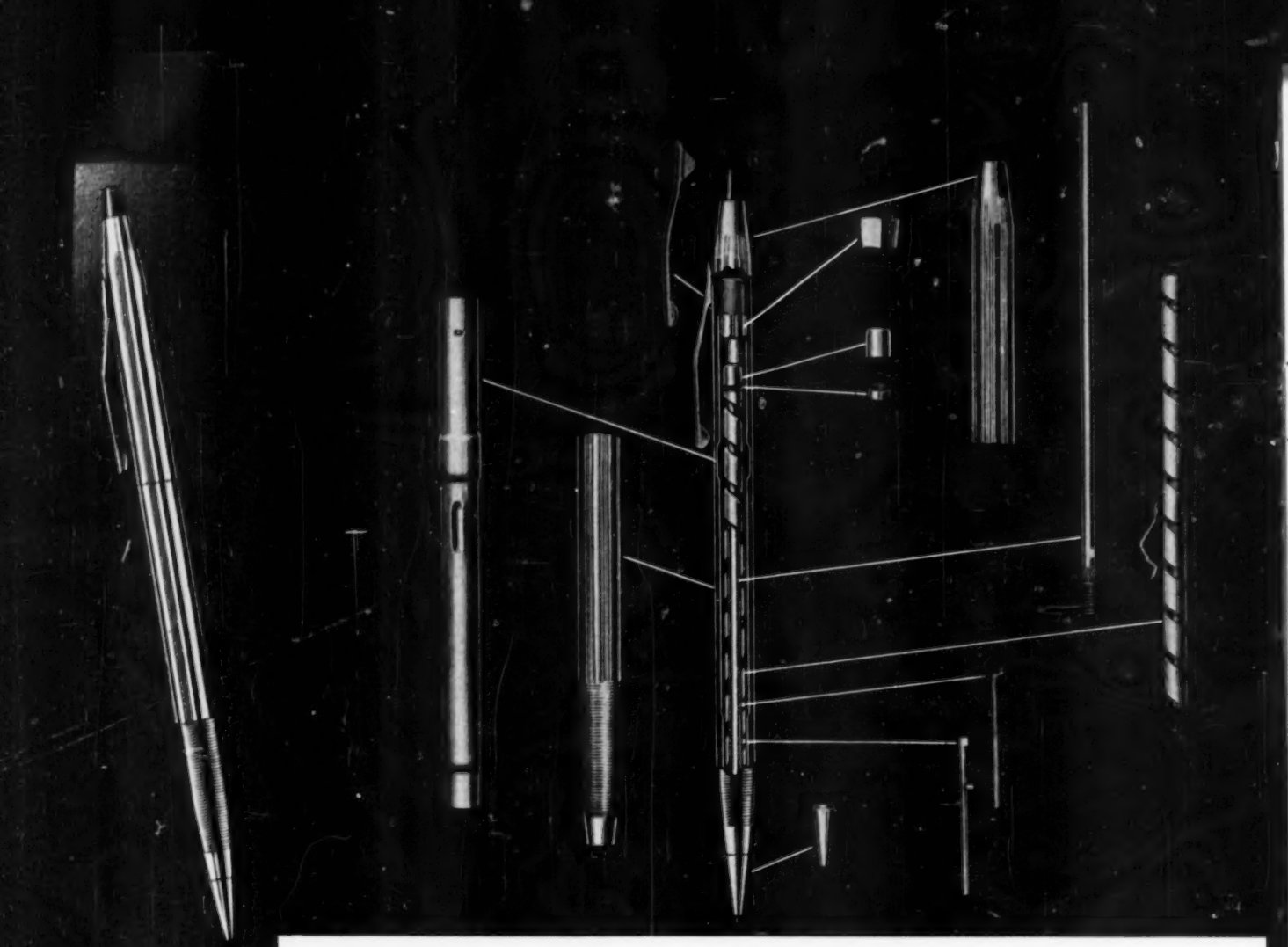
For the housing, steam generator, filler tube and miscellaneous supporting members, BRASS was the answer – as it so often is where freedom from rust, resistance to corrosion, workability and ease-of-finishing must be coupled with moderate cost.

We are glad to report that Dominion's choice and extensive use of Anaconda Brass paid off handsomely; also that we were able to give their engineering and production staffs an assist in selecting the right compositions and the most economical gages and tempers. Perhaps we can do the same for you? Simply write The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 5489

ANACONDA

the name to remember in

COPPER • BRASS • BRONZE



CROSS put an end to automatic pencil troubles **with BRASS**

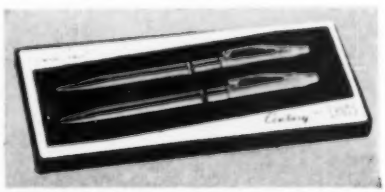
Since 'way back in 1846, America's oldest manufacturer of fine writing instruments—the A. T. Cross Pencil Company, Providence, R. I.—found out that you can do things with brass that you can't do with any other metal. And they've been doing it ever since.

Illustrated above in actual size are an even dozen parts that make up the chromium plated Cross Pencil. All, except the spring clip of phosphor bronze, are made of brass supplied as sheet, strip, wire, rod or tube.

Note the multiplicity of fabricating operations—from the free cutting brass point to the strip-wound spiral—and you'll come to the conclusion that brass gives you the most "easy workability" for your money.

And the man who owns a Cross Pencil—or Pen—is far less apt to fume or fuss. He's got a writing instrument that's tops in quality at a moderate price, with parts that resist wear and corrosion . . . that won't rust, gall or "freeze."

Dependable brass is plentiful—and unrestricted. The days of substitutes are over. Next time the man at the drawing board looks up and says "What'll it be," say "Make it brass." Better yet, say "Anaconda Brass." The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

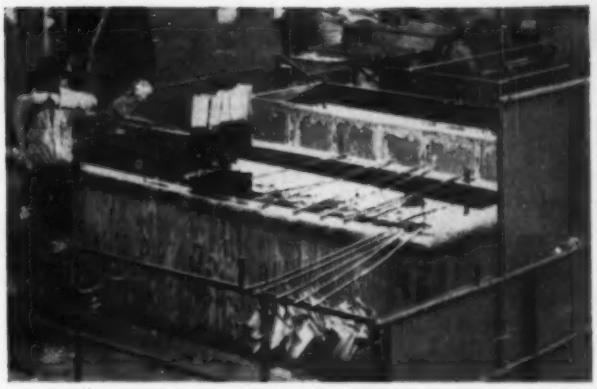


In the exploded view, above, is featured the pencil of the A. T. Cross Chromium Plated Pen and Pencil Set. All parts, including those in the pen, are made of Anaconda Alloys supplied by The American Brass Company since 1913. Cross also uses the same "inside working parts" in two "Century" Pen and Pencil Sets in which the caps, barrels and clips are available in either sterling silver or 1/20 12K gold-filled (illustrated above).

ANACONDA

the name to remember in

COPPER • BRASS • BRONZE



To these well-known benefits you get with HOUGHTON SALTS

• VERSATILITY

Houghton Liquid Salt Baths cover a temperature range of 350° F. to 2400° F. for drawing, martempering, annealing, quenching, carburizing, nitriding, normalizing and hardening of both ferrous and non-ferrous metals.

• FAST HEATING

Since thermal conductivity from salt to metal is exceptionally high, Houghton Salts bring your parts up to heat faster than is possible with other methods.

• PRECISION

Temperatures of modern salt baths can be controlled within two or three degrees. So Houghton's doubly-refined salts give you the same close tolerances you demand in your machine shop . . . batch after batch.

...Add Service!

Houghton's research staff works closely with the metalworking industry in servicing salt baths. So a valuable ingredient that is not in the formula goes with every Houghton Salt you buy—the long experience and wide knowledge of your heat treating problems. Ask the Houghton Man for help he'll be glad to give you—or get for you!

Get *"Liquid Salt Baths"* book by writing to E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pennsylvania

LIQUID SALT BATHS

. . . products of

E F HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

Personals . . .

William Dean Walther, who received his D.Sc. degree from Massachusetts Institute of Technology in 1954, is now employed as research engineer in the scientific laboratory of Ford Motor Co., Detroit.

Joseph A. Charbonneau, former employee of the General Electric Research Metallurgical Laboratory, is now employed as a research engineer by North American Aviation, Inc., Ingleside, Calif.

Versey H. McBride is now quality control manager at Wallace Aviation Corp., Wallingford Park, Conn.

Charles H. Hutchinson, a former staff member of Sandia Corp., Albuquerque, N.M., has taken a position as associate aeronautical engineer with Cornell Aeronautical Laboratory, Inc.

Jacob Schramm, former employee of Metall-, Guss- und Presswerk Heinrich Diehl, Nuremberg, Germany, is now employed at Westinghouse Electric Corp., East Pittsburgh, Pa.

L. D. Cook, Jr., formerly head materials engineer, Wyandotte Chemicals Corp., Wyandotte, Mich., has joined the Bart Mfg. Corp. of Belleville, N.J., as sales engineer. He has been appointed Detroit district representative.

Paul H. Anderson, upon completing three years of teaching in the department of metallurgy at the Colorado School of Mines, resigned to accept a position as associate professor and acting head of the department of metallurgy at the South Dakota School of Mines and Technology.

Sigmund L. Smith has left the Colorado School of Mines to accept a pos'tion as professor in the department of metallurgy of the College of Mines, University of Arizona.

Ralph W. Donley is now employed as engineer, new devices, with Bendix Products Div. of Bendix Aviation Corp., South Bend, Ind.

Charles Keshlear has been assigned to the 44th Bomber Wing at Lake Charles Air Force Base, La., as a field service engineer for Boeing Airplane Co.

C. W. Jordan, Jr. has accepted a position as technical engineer in the engineering laboratories of International Business Machines Corp., Endicott, N.Y.

Richard E. Grace has joined the faculty at Purdue University as assistant professor of metallurgical engineering. A graduate of Purdue University in 1951, Dr. Grace did graduate work at the Carnegie Institute of Technology where he recently received his Ph.D.

James Riddle, who has been employed as a research technician by Pratt & Whitney Aircraft, East Hartford, Conn., has returned to Texas Western College to complete his last year for a B.S. degree in mining and metallurgy.

I. C. Sleight is now head of the inspection department at Aerojet-General Corp., Azusa, Calif., following his resignation from the Naval Ordnance Test Station, Inyokern, Calif.

Donald E. Coran is now employed as group supervisor of the metallurgical and chemical units of process control of Chance Vought Aircraft Div., Grand Prarie, Tex.

William N. Dunlap, Jr., previously employed as project engineer with the Freiz Instrument Div., Bendix Aviation Corp., Towson, Md., has accepted a position as chief chemist and laboratory director with the Reynolds-Robson Supply Co., Philadelphia.

R. S. Dalrymple has resigned from the General Electric Co., Hanford Atomic Products Operation, to accept a position as corrosion engineer in the application engineering group at Reynolds Metals Co., Louisville, Ky.

R. Reed Barton, formerly project engineer and materials engineer at the U. S. Naval Ordnance Plant, York, Pa., is now senior development engineer at Goodyear Aircraft Corp., Akron, Ohio.

Jerome L. Bogus has been elected president of Jelco Finishing Equipment Corp., New York City.

James P. McNally, formerly plant metallurgist at the Carrier Corp., Syracuse, N.Y., has accepted the position of metallurgist with the Bart Mfg. Corp., Belleville, N.J.

Donald P. Pennington was recently transferred to the Detroit office of Reynolds Metals Co. as regional sales engineer.

A. C. Keiser, Jr. has been transferred from supervisory lubrication engineer of the Texas Co. at Birmingham, Ala., to chief lubrication engineer of the Atlanta, Ga., division.

Paul W. Kloeris, Jr. is now employed as a metallurgical engineer with the atomic power division, Westinghouse Electric Corp., Bettis Field, Pittsburgh, Pa.

R. Wayne Kraft, formerly metallurgist in the research center of American Brake Shoe Co., Mahwah, N.J., specializing in cast iron research, is now an instructor in the College of Engineering, University of Michigan.

Bruce W. Capek is on a military leave of absence from the Esso Standard Oil Co., Baton Rouge refinery. After attending the Officer Candidate School at the U. S. Naval Station in Newport, R.I., Mr. Capek was commissioned ensign, and is presently stationed at the U.S. Naval Ordnance Plant in Macon, Ga., as assistant to the production officer.

Since Sept. 1, 1954, **Jess C. Little** has been manager of the electrical division of Fanner Mfg. Cc., Cleveland.

Darold L. Griffin is employed as a research and development engineer in the magnesium laboratories of the Dow Chemical Co., Midland, Mich.

Following the acquisition of Canadian Steel Improvement, Ltd., by High Duty Alloys (Canada), Ltd., **R. G. Murley** was appointed sales manager of the former.

James G. Darrah is now studying for his Ph.D. degree under the Du Pont Fellowship in metallurgy at Lehigh University and working on deformation characteristics of single crystals.

Pelletizing Practices for Iron Ore*

THE INCREASING fineness of iron ore concentrates causes such high dust losses in sintering machines that greatly increased interest in pelletizing has spread around the world. At present the finely divided taconite concentrates in Minnesota (80% under 200-mesh) are being agglomerated by pelletizing in preference to older processes. Sweden has used agglomerated ore charges for more than 50 years, and today more than 90% of the ore burden charged into blast furnaces in that country is either sintered or pelletized.

Since the main constituent of Swedish iron ores is magnetite, it was early realized that this dense material is much more difficult to reduce than hematite. Formerly every Swedish blast furnace had roasting furnaces for the purpose of heating coarse magnetite ore under strongly oxidizing conditions to convert the iron mineral to Fe_2O_3. Later the sintering plants were also operated so as to produce a well-oxidized sinter. Although most of the iron ore sinter during 1910 to 1935 contained little hematite (2 to 4%), today Swedish sinter contains over 90% hematite.

Great interest arose in Sweden in pelletizing after the publication of the results obtained by Davis and his associates in 1946 at the Mines Experiment Station of the University of Minnesota. Pellets appeared to be ideal raw material for the shaft-type sponge iron plants and a committee was formed by Jernkontoret to investigate the possibilities of this method. Work at the plant and in laboratories of the Institute of Technology, Stockholm, indicated that many intricacies were involved in the manufacture of satisfactory pellets, and over three years of intensive work was required before good results with Swedish ores were possible. It was found that each type of iron ore required its own special operating procedure to produce a satisfactory pellet.

Many factors were encountered, close control of which must be maintained in the making of pellets. The more important are listed below:

1. Particle size of ore should be very fine, about 80% under 250-mesh.
2. Water content (8 to 10% water for fine magnetite concentrates) of balling charge should be very closely controlled.
3. Rotating drum for forming green pellets should be about 2 to 3 times as long as the diameter, inclination of drum to outlet 2 to 3°, peripheral speed of drum 270 ft. per min. for ⅝-in. diameter balls.
4. Green pellets must be strong enough to withstand a drop of about 3 ft. without cracking and have a crushing strength of 4½ lb. for the ⅝-in. size in order to pass through a vertical shaft furnace without much loss due to dust and breaking.
5. Firing temperatures of at least 2100 to 2280° F. are desirable without the pellets fusing together. The critical "sticking" temperature varies for different ores.
6. The amount and chemical composition of the gangue in the ore have a pronounced effect on the quality of pellets produced.
7. Strongly oxidizing conditions are necessary to convert the mag-

(Continued on p. 152)

*Digest of "Aspects of Pelletizing of Iron Ore Concentrates", by Magnus Tigerschiöld, *Journal* of the Iron and Steel Institute, Vol. 177, May 1954, p. 13 to 24.

STRIPPING ENAMEL . . .

SAVING TIME

Enthonics AT WORK

25 seconds from immersion to completed stripping!

That's the fast, dramatic story of ENTHONE Enamel Stripper S-18 in action — another example of *Enthonics at work.**

Enthone Enamel Stripper S-18 is the modern organic stripper developed for removing the newest organic finishes such as Epon or Epoxy coatings and many synthetic enamels from copper, copper alloys, steel and aluminum.

For the right strippers to solve your organic stripping problems fill out a questionnaire we'll send at your request; return it with typical samples of your work. Enthonics will find the answer . . . without obligation!

And ask for your copy of the "Enthone Check List" of literature covering more than 60 products and processes developed for modern electroplating and metal finishing.

* *The Scientific Solution of Metal Finishing Problems*

ENTHONE INCORPORATED

METAL FINISHING PROCESSES

442 ELM STREET, NEW HAVEN 11, CONNECTICUT

ELECTROPLATING CHEMICALS

Service Representatives and Stock Points: BINGHAMTON, N. Y., Austin F. Fletcher, Inc.; CHICAGO, Ardco, Inc.; CLEVELAND, R. O. Hull & Co.; DALLAS, Weaver Engineering & Supply Co., Inc.; LOS ANGELES, L. H. Butcher Co.

netite to hematite in the pellet firing. This improves the fired strength of pellets and increases the rate of reduction in the later smelting stage.

8. Some additives to the ore, such as 0.25% Wyoming Bentonite and 1 to 5% calcium oxide, greatly increase the strength of the green, dried and fired pellets.

9. Ball size is critical. For a given ore mix a larger output of ⅝-in. diameter balls of much greater green and fired strength will result than when 1¼-in. balls are made from the same mix.

It is surprising that good-quality pellets can be made on a large scale in vertical shaft furnaces. To charge wet green pellets into a vertical furnace, to dry and heat them rapidly to a high temperature under an increasing load without shattering, followed by baking at a high temperature (2100 to 2280° F.) without the pellets fusing or sticking together, requires the closest control over charging and discharging rate, temperature, and uniformity of gas flow up the shaft. Furnaces for baking may be either round or rectangular but should not be more than 6 ft. wide. The furnace is fired from an outside oven using excess air and about 32.2 lb. of fuel oil per 2200 lb. of pellets. Air for combustion is blown over hot pellets discharged to cool the pellets and to preheat the air. The output of pellets varies from 4400 to 11,000 lb. per sq.ft. of furnace hearth area per day. It is affected by pellet size, firing temperature, rate of combustion and type of ore mix involved.

Pelletized ore is of great value in Sweden because it is the raw material for blast furnaces, sponge-iron plants and openhearths. The preferred size of pellets is 1¼ in. diameter and the hematite content is over 99% for all three applications. There are now seven large-scale pelletizing plants operating in Sweden having a total annual output of 250,000 tons per year, and construction of new units may increase this to 800,000 tons. A full-scale American-type pelletizing plant will be built at Kirkenes, Norway.

The results of research in the U.S.A. on methods of producing a satisfactory concentrate from magnetitic taconite ores has emphasized that extremely fine grinding is necessary. As a result, pelletizing is favored over conventional sintering and many large pelletizing units are now under construction or are being planned to produce millions of tons of pellets per year.

The future of the pelletizing process depends on the possible saving in production cost in comparison with other methods, and also on the value of the product for use in the iron and steel industry. According to Swedish experience, the cost of pelletizing in the moderate-size units hitherto used is not higher than that of sintering. In some instances pelletizing will be less expensive than sintering, as when the available concentrate is very finely milled. The production from ordinary sintering machines will be decreased when treating a fine-mesh material, partly because the amount of returns will be much higher.

The decision to build huge plants in the U.S.A. and Canada is based

(Continued on p. 154)

FILTRATION for AUTOMATION

Delpark

MAKES AN ASSIST ON Quality Control AT IBM

These Zagar pallet-type transfer machines at IBM perform numerous drilling operations on aluminum frames for the famous IBM typewriters.

Here is a fine example of Automation . . . and backing up this unit is automation in filtration. You won't see it in the picture, but . . . Delpark filtration cleans coolant from the 206 drill spindles. Greater accuracy of drill hole size, longer drill life, more efficient tool operation are but a few of the major savings gained through Delpark filtration. Delpark is one reason why up to 144 parts per hour are handled on this unit with but two operators. Credit IBM and Zagar tool engineering for foresight . . . credit IBM tool service for production know-how . . . credit Delpark for filtration as modern as today's automation.

For your filtration problems . . . for automation or normal procedure . . . contact Delpark for competent field engineering. There's no obligation. *Write today.*

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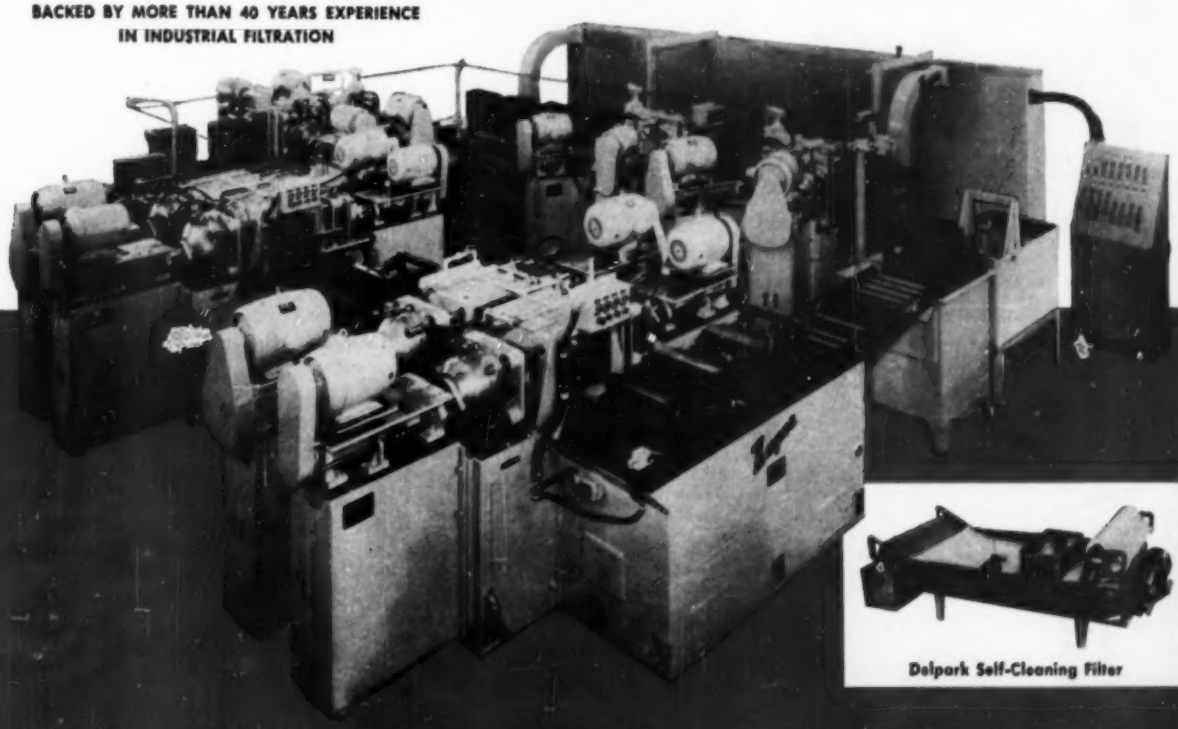
BACKED BY MORE THAN 40 YEARS EXPERIENCE IN INDUSTRIAL FILTRATION



Delpark Self-Cleaning Filter

INDUSTRIAL FILTRATION COMPANY, 116 INDUSTRIAL AVENUE, LEBANON, INDIANA

Pelletizing . . .

on the conviction that the pelletizing method is the best so far found for agglomerating finely milled magnetite concentrates, and also on the experience gained when the pellets were tried in blast furnaces and as charge and ore feed.

In Sweden large resources of magnetite ore are available which often can easily be concentrated to an iron content of over 60% without grinding the product to a high degree of fineness. Thus, most of these concentrates can be sintered effectively for use in blast furnaces. An exception is the Malmberget concentrate, which must be very finely ground when efficient removal of phosphorus is required.

The original reason for Swedish interest in the pelletizing method was the apparent possibility of producing a suitable raw material for the Wiberg sponge-iron furnaces. To achieve the desired high iron content (68% and above) the concentrates have to be milled to about the same fineness as the Mesabi ores. As reported earlier, the necessary agglomeration has been successfully achieved by the pelletizing method.

This method, at least when large shaft furnaces are used, seems to be less suitable for the agglomeration of hematite concentrates and pyrite residues; like most new methods its use will be limited to the treatment of certain types of ore, and it will be a useful complement to the beneficiation of the iron ore resources.

If for some reason the properties of the pellets are superior to those of ordinary sinter, the method will probably prove sufficiently economical even when extra grinding of the concentrate must be done to make pelletizing possible.

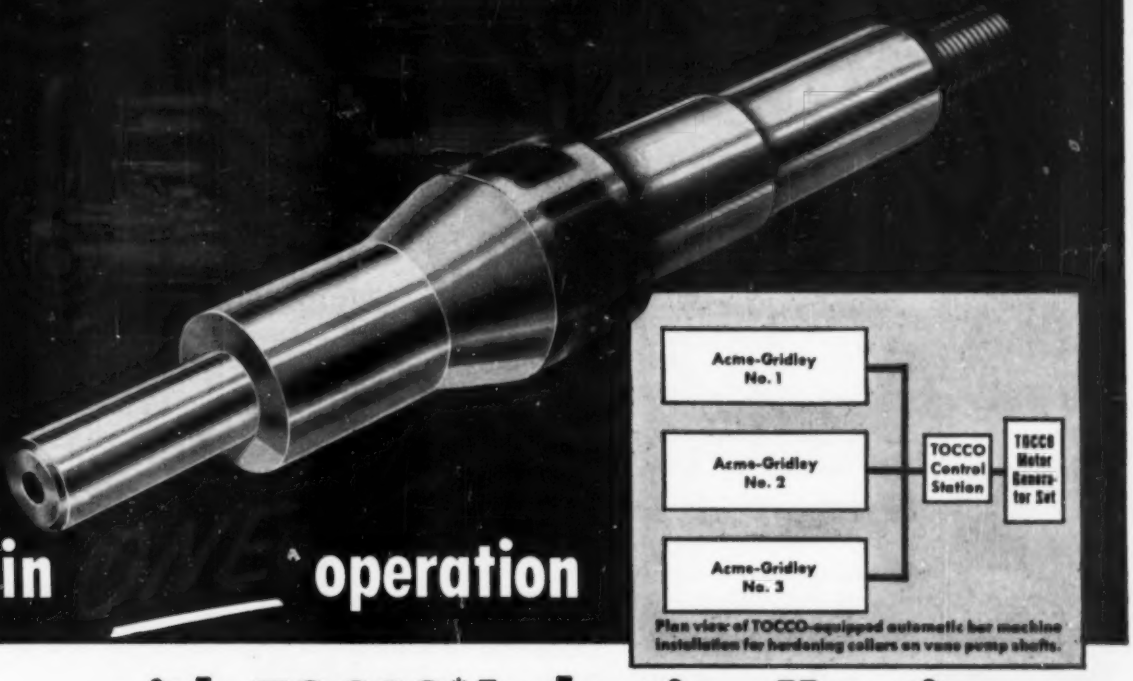
So far, no information has been published on the results achieved when using pellets in blast and open-hearth furnaces. The author reports that blast-furnace operators in the U.S.A. who have once tried pellets insist on always using them. This is understandable in view of the high dust losses that occur when unscreened Mesabi ores are used, and the pellets also are superior to the hard-burned sinter common in the U.S.A. Also, an addition of highly oxidized rich pellets must give a considerable saving in fuel consumption, accompanied by increased production.

At Sandviken and Hofors, only pellets are now used in steel furnaces, and very good results have been achieved. The pellets are richer in iron than the magnetite lump ore previously used, and the amount of oxygen in the ore is increased.. Pure hematite contains 8.7% more oxygen than magnetite so that, for example, the rich Malmberget pellets with 69% iron will contain 14.1% more oxygen than the best Kiruna A magnetite lump ore with 68% iron. Well-burned pellets will save handling and transportation and withstand cracking or abrasion, and should be an ideal charge and feed ore in all types of steel furnaces. The porosity of the pellets is 20 to 25%, the apparent density about 3.95, and the bulk density about 137 lb. per cu.ft.

Most pelletizing plants hitherto constructed are placed at the mines. This is an advantage when the mine is located in districts where freezing makes it impossible or difficult to transport moist concentrates in the winter. The dead freight for the moisture content of the concentrate is also saved if the pelletizing is done at the mine. On the other hand, the specifications for the pellets would be less rigid if handling and transportation of the product could be avoided as much as possible. This is achieved if the pelletizing furnaces are placed at the steel plants.

E. C. WRIGHT

Pump Shafts Machined and Hardened



Plan view of TOCCO-equipped automatic bar machine installation for hardening collars on vane pump shafts.

with TOCCO* Induction Heating

TOCCO-equipped 8-spindle Acme-Gridley Bar Automatics at a large automotive manufacturer's plant produce vane pump shafts for power steering units in one completely automatic operation!* No handling—no hardening cost except power!

A TOCCO inductor, mounted at one station of each automatic, hardens collars on pump shafts after they have been completely machined at preceding stations on the same machine. Each installation consists of 3 automatic machines equipped with inductor coils powered by a 50 KW, 10,000 cycle TOCCO unit. Production from each installation is 360 shafts per hour.

Shafts are made of C 1144 and only the collar is hardened to prevent scoring the seal. TOCCO's rapid heating confines the hardened area to the surface of the collar leaving the rest of the shaft unaffected.

If your products or their components require heat treating, soldering, brazing or heating for forging, it will pay you to investigate TOCCO for better, faster production at lower unit costs.

*A Patented Process

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Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating."

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Thermos Battles*

HEAT has been a major force in affairs long before it was understood – the discoveries of pottery, metals, and glass are milestones. But to work competently with heat it had first to be defined; it is the energy of random motion of molecules and atoms. Second, it had to be measured, both as to its quantity and as to its temperature, the latter specifying the average energy of motion of the particles. Finally, two laws of behavior of heat were set forth: According to the first, energy is conserved – it cannot be created or destroyed. According to the second, heat can flow only from a higher to a lower temperature or, otherwise expressed, energy always tends to run downhill. Thus one cannot convert heat, which is a "low-grade" form of energy, into a higher-grade form, such as electricity, without some sacrifice of efficiency.

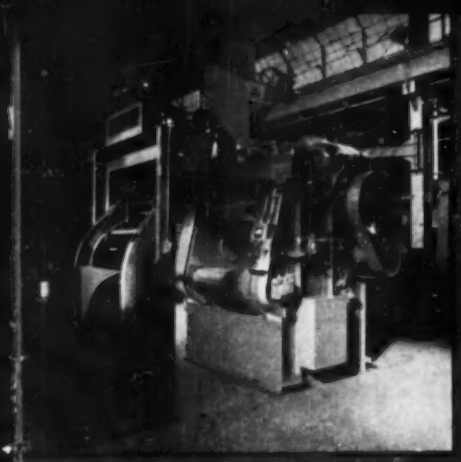
From these simple-sounding but subtle rules thermodynamics has evolved, and has shed light on the behavior of matter, of radiation, and in fact of living things. Temperature regulates the chemical activity of the enzymes, which control the processes of most forms of life, and the enzymes break down or refuse to function outside the range of about 32 to 122° F. Most life would die if the earth's average temperature increased as little as 20° F.!

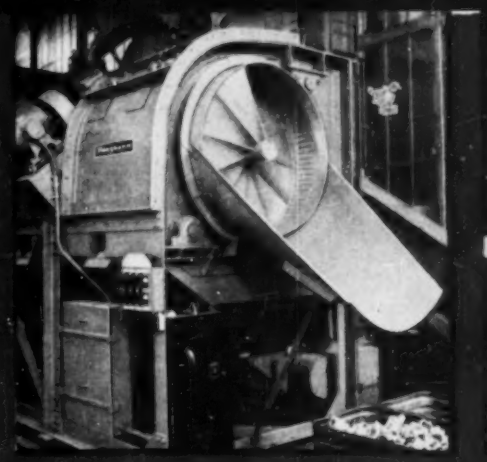
One of the earliest concerns of thermodynamics, and still a fruitful field for inquiry, is the study of fire – from it has grown modern chemistry. Fire is only one form of combustion, that form which emits light. The wood-fire flame is still little understood, but it is known to involve complex reactions, and some of them, in highly specialized flames, can be tapped as sources of valuable by-products.

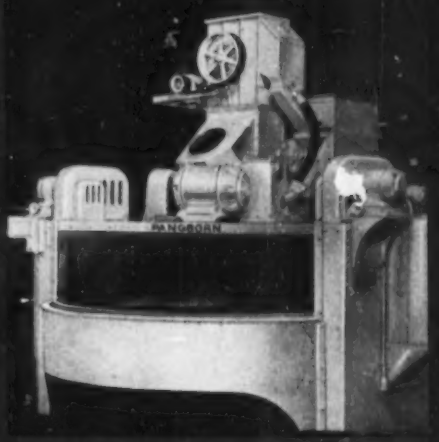
Materials Critical – One bottleneck in the advance of heat technology is imposed by materials. Only 20 natural elements will withstand temperatures up to 3000° F., and rocket designers, who are now thinking in terms of 5500° F. and more, have had to rely on man-made oxides and carbides. Since the efficiency of

(Continued on p. 158)

*From "Industrial Bulletin" of Arthur D. Little, Inc., September 1954.







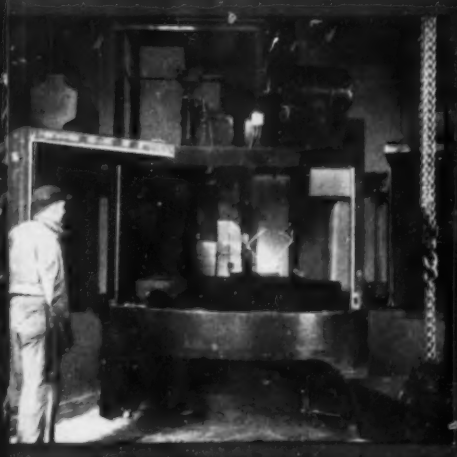
Pangborn's 50 years of progress

offer you a complete line of equipment for every blast cleaning and dust control need

Fifty years of know-how . . . a half-century of research and development . . . and today Pangborn Blast Cleaning and Dust Control Equipment promises *and delivers* better, faster, cheaper performance on any foundry job. Shown here are just a few machines from Pangborn's *complete line* of equipment.

Pangborn engineers and equipment can save *you* time, labor, and money. Our engineers will be happy to work closely with you, in recommending the exact Pangborn unit you need, and in developing new equipment when necessary. No matter what you clean —large or small castings, ferrous or non-ferrous work . . . or whatever dust problem you have, it will pay you to find out how Pangborn can help you.

Send for the Pangborn bulletins that fit your needs. Write: PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md.



Thermos Battles . . .

a heat engine increases with the temperature difference maintained in it, there is a constant demand for new materials to withstand ever higher temperatures. Some metals and some ceramics, as well as blends of the two, show promise, but special techniques may have to be relied upon to reach the probable limit, which one estimate places at 10,000° F.

The present frontier of chemistry lies in the range of 1800 to 5400° F. Here progress has been measured by accomplishment; one chemical plant makes 40 tons of nitric acid per day by rapid chilling of nitric oxide from 3800° F. At such temperatures, chemistry is far from traditional. There is no liquid water, there are few solids, no complex molecules. Mostly there are simple gases that react rapidly to form chemicals difficult to obtain any other way. Today's problem is how to recover them for industry tomorrow, by applying our growing understanding of heat.

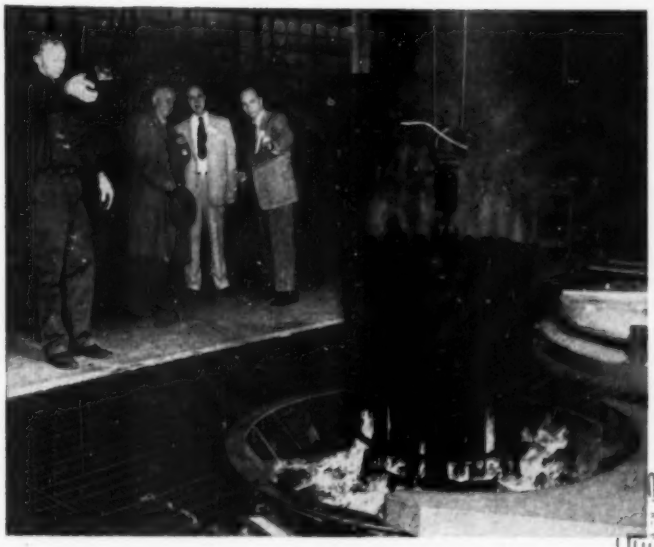
One of the *Scientific American* articles in the September issue outlines the implications of fast chemical reactions in the field of propulsion. Gasoline and diesel engines owe their present efficiency largely to research in the thermodynamics of fuel combustion. But as in all heat engines, higher efficiencies can come only from using higher compressions. In gasoline engines, this introduces engine knock; in diesel engines, it entails excessive weight. For high-speed flight, the answer appears to be in various froms of jet propulsion, wherein heat energy is transformed directly into propulsive work. Such devices can be relatively simple and light weight. Rockets, for example, take in no air, as a gasoline engine must. They carry their own oxidizer, such as liquid oxygen, to promote burning of fuel and therefore can function outside the earth's atmosphere.

Very High Temperatures – All the variants of the jet propulsion mechanism convert heat into kinetic energy by expanding hot gases through a nozzle, and all heat their fuel gases to high temperatures by chemical reactions. Thus it is important to carry fundamental research to very high temperatures, in

(Continued on p. 160)

The Park Triple A Story:

"Park Quench Oil gives us faster, deeper hardening with much less distortion,"



says AL RIDINGER,
President of METALLURGICAL, INC.

At Metallurgical's new 40,000 sq. ft. plant in Minneapolis, Al Ridinger (right) shows Charles Wesley (left), President of Wesley Steel Treating, Milwaukee, a quenching process as Larry Ridinger (center), Company Vice President, looks on. Here, wing flap tracks for B-47 Jet Bombers are being quenched in a modern 8000 gallon system in which Park Triple A oil is circulated at the rate of 2000 gallons per minute. Using the latest type equipment, Metallurgical serves over 28 major industries in the North Central area.

PARK TRIPLE A QUENCH OIL was developed specifically to *cool steel faster* in the upper temperature ranges, giving higher and deeper hardness. The final stage of cooling is *slow and uniform* for the best surface hardness and depth of hardness penetration without danger of warping or cracking. *Extremely stable,* Park Triple A is not subject to breakdown, saponification or rancidity.

Higher hardness, less distortion and longer life —Park's *Triple Action* Quench oil . . . suitable for use as a quench from any heat treating medium . . . highly recommended for obtaining maximum hardenability.

• Liquid and Solid Carburizers • Cyanide, Neutral, and High Speed Steel Salts • Coke • Lead Pot Carbon • Charcoal • No Carb • Carbon Preventer • Quenching and Tempering Oils • Drawing Salts • Metal Cleaners • Kold-Grip Polishing Wheel Cement

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Thermos Battles . .

the range of 7000 to 45,000° F. and higher. Such temperatures can be generated momentarily in the laboratory, using a "shock tube" wherein rapid pressure jumps or "shock waves" can heat gases to 18,000° F. or more.

Temperatures beyond those obtainable in the laboratory exist in the stars. Links between terrestrial and celestial observations have already been established. At very high temperatures gases are found to be strongly electrified, and should be influenced by magnetic fields. Solar prominences show just such an effect, as well as the magnetic effects that would be expected to accompany these hot gases in motion.

Some Advantages of Vacuum Melting and Casting*

THE ELIMINATION of impurities from metals permits the study of their properties and the determination of the effect of variation in alloy content without interference from impurities which might otherwise completely mask it. To conduct such research, a vacuum melting and casting unit was designed to permit casting of shapes which would require a minimum of hot working, and hence minimize subsequent contamination, particularly by carbon, hydrogen, and nitrogen.

The unit was of the quartz tube type, with an external induction coil around a jacketed, water-cooled quartz chamber containing the crucible. A water-cooled copper mold was clamped to the bottom of the chamber, and tapping could be accomplished by a solenoid-actuated stopper rod which sealed the tap hole in the crucible. Alloying additions could be made from a side tube on the chamber by means of a solenoid-actuated plunger in the tube, and with the aid of a funnel over the crucible.

(Continued on p. 162)

*Digest of "Preparation and Casting of Metals Under High Vacuum", by J. D. Fast, A. I. Luteijn and E. Overbasch, *Philips Technical Review*, Vol. 15, 1953, p. 114.

Vacuum Melting . . .

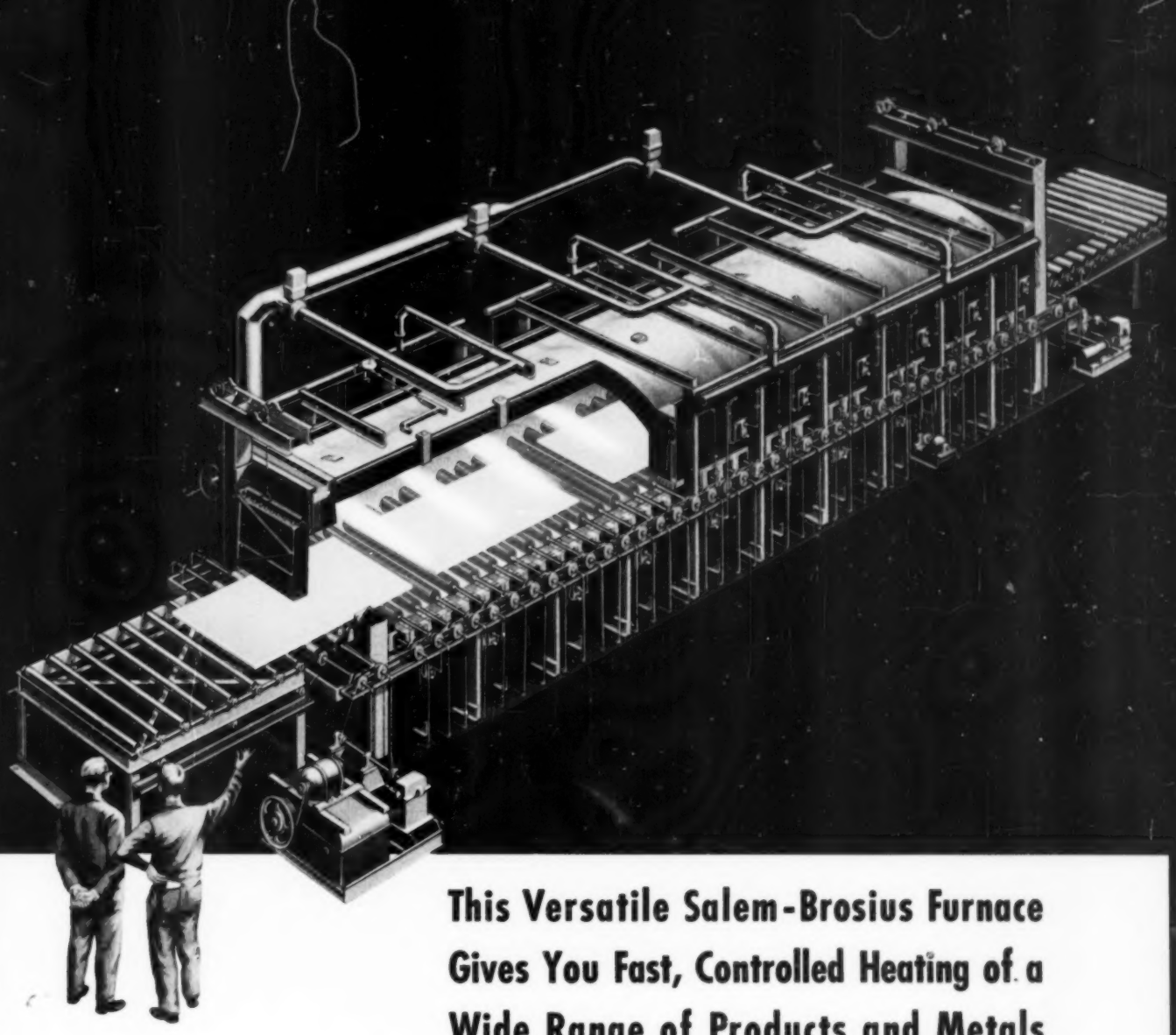
Much of the melting was done in a hydrogen atmosphere, to deoxidize the melts, particularly of nickel and iron. After deoxidation, the furnace had to be evacuated to a pressure of 10^{-3} mm. mercury to avoid hydrogen blowholes in the casting. To prevent the loss of volatile additions, a pressure of argon could be introduced. Additions of very reactive elements, such as aluminum and zirconium, were made after thorough deoxidation. During the application of vacuum, volatile impurities could be eliminated. For example, manganese could be reduced to less than 0.001%.

The selection of crucibles was found to be quite important, not only because of reduction of the oxides by carbon in solution but also by molten iron. Because of the difference in volatility of magnesium and aluminum, the residual impurities found when iron was melted in magnesia and alumina were 0.0016% Mg and 0.027% Al, respectively, thus indicating the superiority of magnesia as a crucible material.

The influences of impurities on the impact strength, aging, and strain-aging characteristics, and anelasticity of highly pure iron have been studied extensively and reported in other papers. Alloys of the 80% Ni, 20% Cr type have been made in very clean condition. Soft magnetic alloys were found to have considerably improved properties after vacuum purification. For example, the coercive force for a 40% Ni, 60% Fe alloy was reduced from the best conventional value of 0.2 oersted to 0.04 oersted for the vacuum-melted product.

While the apparatus produced a charge of only about 4.5 lb., and was used primarily for research, it was adequate for the production of special alloys used in very small quantity, such as fine wire. The very low gas content in the vacuum-cast metals is an essential property for many electronic tube components, such as lead-in wires which may cause leaky seals by gas evolution. Internal components which evolve gas during use lower the life of the tubes. Thus, the elimination of the factor of gas evolution is concluded to be a great advantage in the development of new electronic tubes.

JAMES H. MOORE



This Versatile Salem-Brosius Furnace Gives You Fast, Controlled Heating of a Wide Range of Products and Metals

This roller hearth furnace, designed by Salem-Brosius, gives you fast, automatic control of heating for a variety of shapes and types of metals.

High temperature non-ferrous alloys, steel, brass and aluminum in slabs, sheets, packs, flat bars—even trays of small parts—are heated in this type furnace. This installation heats high temperature alloy sheets to 2250°F at rates up to 7500 pounds per hour. Typical sizes of slabs and packs heated in this 38-foot furnace will range from 40 x 71 inches to 58 x 95 inches.

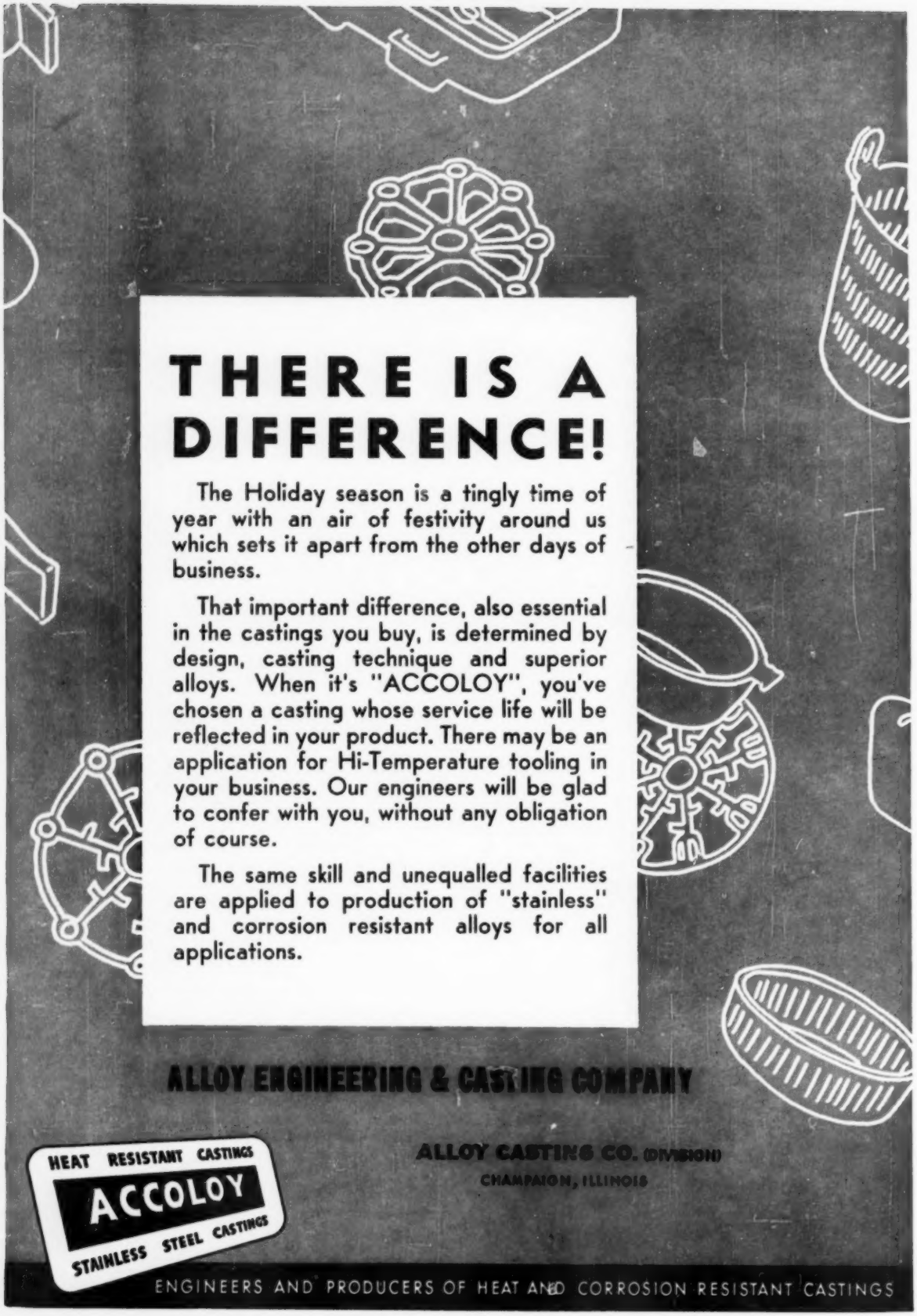
Heating is precisely controlled to within extremely narrow limits through three zones by automatic indicating-recording pyrometers and thermocouples.

The material moves through the furnace on a roller hearth which consists of a series of Hastelloy water-cooled rolls. This furnace has operated for more than 3800 hrs. without roll replacement—an outstanding achievement for such furnaces. Sound design and top-quality materials and components, such as efficient burners and devices for close control of operating temperatures are your assurance of long, trouble-free, economical operation.

As a leader in the field of designing, fabricating and installing precise heating and heat-treating furnaces, Salem-Brosius recently augmented its technical skills by the acquisition of the George J. Hagan Company—now offers you the combined special talents of both organizations in solving your heating problems. To learn how you may improve your heating practice, and increase production with economy, ask to have an engineer call. He will be glad to study your problem and submit a recommendation.

SALEM-BROSIUS, INC.

EXECUTIVE OFFICES: 248 FOURTH AVENUE, PITTSBURGH 22, PA.


THERE IS A DIFFERENCE!
The Holiday season is a tingly time of year with an air of festivity around us which sets it apart from the other days of business.
That important difference, also essential in the castings you buy, is determined by design, casting technique and superior alloys. When it's "ACCOLOY", you've chosen a casting whose service life will be reflected in your product. There may be an application for Hi-Temperature tooling in your business. Our engineers will be glad to confer with you, without any obligation of course.
The same skill and unequalled facilities are applied to production of "stainless" and corrosion resistant alloys for all applications.
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HEAT RESISTANT CASTINGS
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STAINLESS STEEL CASTINGS
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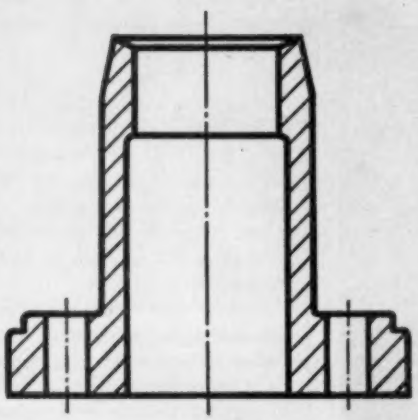
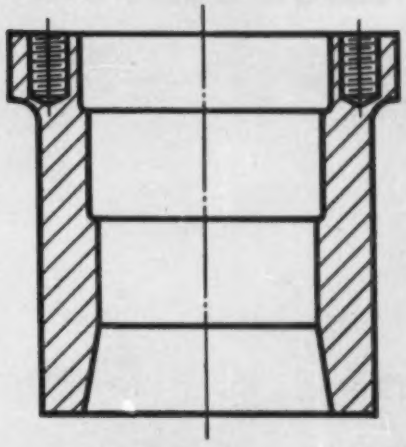
ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

HOW TO MAKE RING-SHAPED TOOL STEEL PARTS FASTER AND EASIER

FORMING AND PIERCING DIE



BLANKING AND FORMING DIE



Graph-Mo Hollow-Bar comes in sizes from 4 to 16 inches O. D. with various wall thicknesses. Immediate delivery on many sizes from warehouses of the distributors, A. Milne Co. and Peninsular Steel Company.

New GRAPH-MO HOLLOW-BAR® eliminates drilling— and machines 30% faster

YOU can eliminate the time-consuming drilling operation when you make ring-shaped tool steel parts from Graph-Mo Hollow-Bar®. The hole comes ready-made. First step is finish boring. There's less scrap, and you use less steel.

On top of that, the rest of the machining's faster—30% faster, compared to other tool steels. That's because Graph-Mo has free graphite in its structure. It means less tendency to pick up, scuff and gall, too.

That same graphite plus diamond-hard carbides give Graph-Mo amazing wear resistance. Users have written us that Graph-Mo outwears other tool steels, on the average, three to one!

Graph-Mo responds uniformly to heat treatment. And no other tool steel is as stable. Proof: after 12 years, a typical Graph-Mo steel master plug gage changed less than 10 millionths of an inch in dimension!

More facts about Graph-Mo Hollow-Bar? Write The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Studies Reveal Purity of Steel Deoxidized With Titanium*

THE PROCEDURE used by the National Physical Laboratory to deoxidize steel consisted of treating melts of electrolytic iron of the highest obtainable purity with varying amounts of chemically pure Fe_2O_3 and sponge titanium which contained 99.7% Ti, 0.25% Fe, 0.035% Mg, 0.025% Si and 0.050% C. In all, 15 different melts were made with additions of 0.034 to 0.10% oxygen and 0.05 to 0.45% titanium. Melting equipment and practice are described in previous papers.

A microscopic examination of complete half-sections of two ingots to which large initial additions of titanium had been made revealed considerable segregation of inclusions into groups. This segregation was quite heterogeneous, except for a high concentration of inclusions in the top layer of the ingot which was about 2 mm. thick. Removal of this layer and thorough filing of the outside surfaces of the ingots to remove occluded refractory material made it possible to get fairly uniform samples for further study.

The ingots were next quartered longitudinally and samples taken as follows:

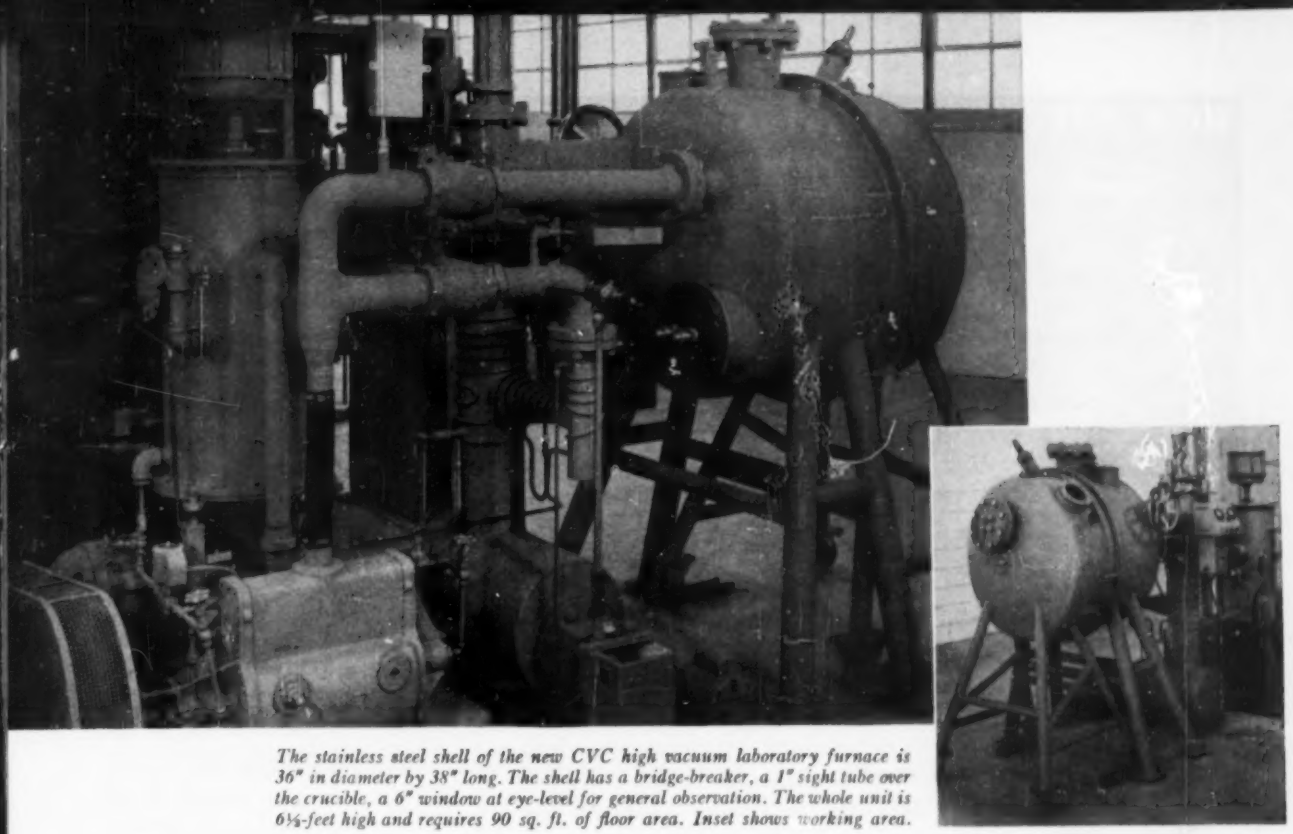
1. Cylindrical samples for vacuum-fusion analysis.
2. Two 10-g. slices 1 mm. thick for alcoholic iodine extraction; one for chemical analysis and one for X-ray examination of the residue.
3. Millings for chemical analysis of titanium.

The cylinders and slices were taken from center cuts of the ingots whereas most milled samples were taken from complete longitudinal sections of the ingots.

Results of the various analyses are tabulated. The total oxygen content determined by vacuum fusion of metal samples and calculated from the assumed oxide content of the iodine extraction residues is shown. Some ingots showed close agreement while others had a wide variation in

(Continued on p. 166)

*Digest of "Deoxidation of Steel With Titanium", by E. L. Evans and H. A. Sloman, *Journal* of the Iron and Steel Institute, Vol. 174, August 1953, p. 318-325.



The stainless steel shell of the new CVC high vacuum laboratory furnace is 36" in diameter by 38" long. The shell has a bridge-breaker, a 1" sight tube over the crucible, a 6" window at eye-level for general observation. The whole unit is 6½-feet high and requires 90 sq. ft. of floor area. Inset shows working area.

CVC announces

a new high vacuum metallurgical research furnace

Every part of *CVC*'s new high vacuum laboratory furnace is designed for precise control and operating convenience. Here are the outstanding features—

1. Large vacuum pumping capacity is provided by *CVC*'s KS-600, *2-stage diffusion-ejector pump* which creates the low pressures (of the order of 10^{-4}mm Hg) required for a gas-free atmosphere, and provides ample capacity (up to 0.75mm Hg) for handling the pressure surges that occur during alloy additions and pouring.

2. You perform general observations, alloy additions, tilt pouring, optical and/or thermocouple temperature measurements, bridge-breaking, pressure readings, and high frequency control *all from one spot*.

3. A single semi-automatic, rotary sequence switch controls the pneumatically-operated valves, thus eliminating the need for manual operation.

4. You have a choice of five crucible sizes to accommodate melts of 5, 12, 17, 30 or 50 pounds.

5. Pre-pouring pressures range from 1 to 10 microns for a 50-pound melt of steel; correspondingly lower pressures are obtained when making smaller melts.

For detailed specifications on this new *CVC* laboratory vacuum furnace and for information on pilot or production type vacuum furnaces, write ***Consolidated Vacuum Corporation, Rochester 3, N. Y.*** (a subsidiary of Consolidated Engineering Corporation, Pasadena, California).

Typical performance of the new CVC high vacuum laboratory furnace with pumping system at normal heater input.

PRESSURE: Microns Hg	SPEED: Liters/Sec.	THROUGHPUT: Micron Liters/Sec.	THROUGHPUT: Micron Cu.Ft./Min.
.2	450	90	191
1.0	660	660	1,400
5.0	750	3,750	7,970
10.0	600	6,000	12,750
50.0	120	6,000	12,750
100.0	60	6,000	12,750

(Selective throughputs may be obtained by using the high, medium, and low heater switch mounted on the KS-600 pump.)

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Titanium Deoxidation . . .

total oxygen. Chemical analyses of the iodine residues for silicon, aluminum, iron and titanium are tabulated, together with the calculated oxygen content of the residue based on SiO_2, Al_2O_3, FeO, Ti_2O_3. Total amount of titanium in the ingots was determined by a colorimetric method. The titanium content of the oxide residues was subtracted from the total titanium to give approximations of the residual metallic contents of the ingots. The only other oxides in the residues besides those of iron and titanium were those of alumina and silica; both of these were very low, being 0.001 to 0.002%. As expected, the Ti_2O_3 content of the residue was high for the higher additions of Fe_2O_3 and titanium to the melt, with the top portions of the ingots always being higher in Ti_2O_3.

The inclusions were extracted by the alcoholic iodine method at 30° C. (85° F.). Debye-Scherrer powder photographs were made with a 19-cm. camera using cobalt Ka radiation and the results are tabulated. When molten iron is deoxidized with an excess of titanium, the main inclusion product is Ti_2O_3. As the stoichiometric balance between titanium and oxygen varies from excess of titanium over oxygen to an excess of oxygen, the deoxidation products in the ingots are found to progress in the order Ti_2O_3, Ti_3O_5, TiO_2, $FeO{\cdot}TiO_2$ and finally Fe_3O_4. Most of the constituents were identified by comparing the X-ray patterns with the data given in the A.S.T.M. index of X-ray diffraction data.

The X-ray procedures and results are discussed extensively in the paper. The oxygen addition to the melts was usually about 0.05%. When the titanium addition varied between 0.20 and 0.45% with this oxygen addition, 90% of the inclusions consisted of Ti_2O_3. One melt with added oxygen of 0.037% and added titanium of 0.065% contained 80% TiO_2 inclusions. A heat with 0.1% added oxygen and 0.05% added titanium contained over 90% ilmenite inclusions ($FeO{\cdot}TiO_2$). A rectangular plot of the Ti-FeO equilibrium observed in this research (2910° F.) shows the typical deoxidation curve.

(*Continued on p.* 168)

Titanium Deoxidation . . .

The principal product of deoxidation of iron by titanium, which occurs in inclusions when the residual titanium exceeds about 0.2% (by weight) is Ti_2O_3, with which a little TiO may sometimes be associated. As the excess of titanium decreases, higher oxides of titanium are found, notably anosovite, Ti_3O_5, and rutile, TiO_2. As the proportion of titanium to oxygen changes from excess titanium to excess oxygen, the over-all compositions of the inclusions change accordingly, and compounds range from titanium oxide to ilmenite, an iron-oxide-titanium-oxide spinel, and magnetite. The complete series presumably ends with wüstite, although no evidence of this was obtained. These compounds may be found either alone or more generally as mixtures, the inclusions being duplex in appearance.

E. C. WRIGHT

Time-Temperature Parameters for Creep and Rupture of Aluminum*

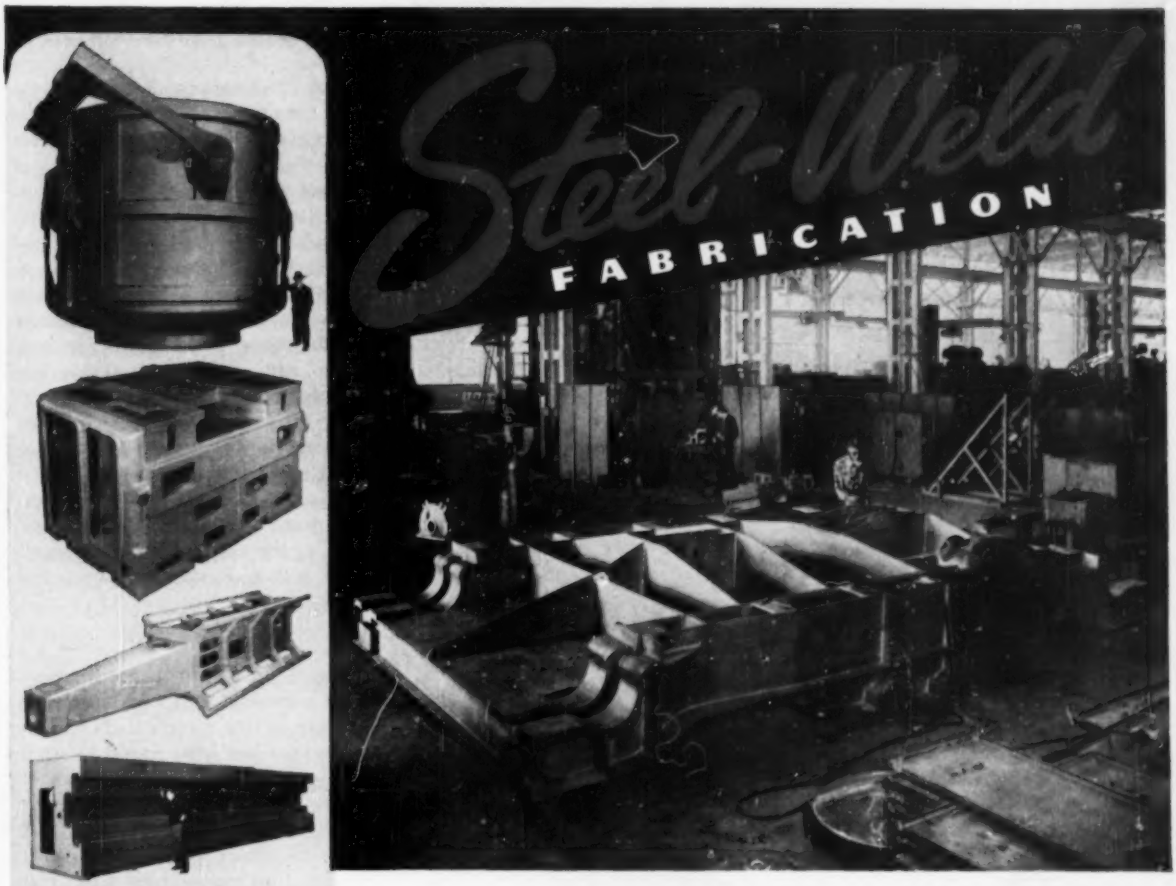
MANY attempts have been made to formulate relationships for stress, strain, strain rate, and temperature in order to predict the strength and behavior of materials at elevated temperatures. The attempts have not generally been too successful.

A promising approach, with considerable practical significance, has been the use of time-temperature parameters for analyzing stress-strain, rupture, and creep data. Various parameters, consisting of some combination of time, or rate, and temperature, together with suitable constants, have been proposed by various investigators.

With such parameters, a single or master curve of stress against the parameter can frequently be obtained for a given material and application over the entire time or rate and temperature range. Thus, equiv-

(Continued on p. 170)

*Digest of "Time-Temperature Parameters and an Application to Rupture and Creep of Aluminum Alloys", by George J. Heimerl, National Advisory Committee for Aeronautics, Technical Note 3195, June 1954.



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Creep of Aluminum . . .

alent combinations of time or rate and temperature can be readily ascertained for any level of stress and the need for whole families of curves is eliminated. These parameters are also of great value in extrapolating test results. Comparisons of predicted values, based on short-time data, with actual test values have shown that accurate predictions of long-time performance are possible with such parameters. The necessity for making extensive long-time tests at elevated temperatures appears to be greatly reduced or even eliminated.

Most of the parameters proposed are based on rate-process theory. One of the simpler of these parameters is that proposed by Larson and Miller, namely:

$$T\,(C + \log t)$$

where T is the absolute temperature, C is a constant and t is the time to rupture or to a specified strain. This parameter has been found to work satisfactorily over a wide range of time and temperature for many steels, high-temperature alloys, and some aluminum alloys. A somewhat similar time-temperature parameter has been proposed by Sherby, Orr and Dorn; a rate-temperature parameter has been proposed by MacGregor and Fisher.

Another recent parameter, proposed by Manson and Haferd, has an experimental rather than a theoretical basis. For use with stress-rupture and creep data, the parameter is expressed by:

$$\frac{T - Ta}{\log t - \log ta}$$

in which Ta and ta are constants of temperature and time, respectively. This parameter has been found to work well for many steels, high-temperature alloys and aluminum alloys over a wide range of times-to-rupture.

When these two parameters are compared, the Manson-Haferd parameter seems to give more accurate predictions of rupture life. The comparison was based, however, upon the assumption that a value of 20 could be used for C (in the Larson-Miller parameter) for all materials. Better correlation with the data can be obtained sometimes if

a value of C other than 20 is used and the accuracy of predictions that can be obtained from the two parameters might then be more nearly comparable.

The accuracy of predictions obtainable from the Larson-Miller parameter or the Manson-Haferd parameter for a given material depends very largely upon the value of the constants which are used. Satisfactory results can be obtained from either parameter if the data can be made to correlate well with the master curves.

Because of the adequacy and simplicity of the Larson-Miller parameters, they were applied to published data for some aluminum alloys. The master curves thus obtained show that these parameters can be applied to most aluminum alloys for rupture, minimum creep rate, and time to obtain 1% strain. Fairly extensive data are needed to determine whether the parameter provides a satisfactory correlation over the entire range of stress.

A value of 20 for the constant C gave good correlation for about half the aluminum alloys considered. To provide good correlation for the others, values from 16 to 40 were used for the constant. Different constants were sometimes required in the parameters for rupture, minimum creep rate, and time to 1% strain for a given alloy.

Consistent results were evident for 2024-T 3 (24 S-T 3) even though independent sets of data from different laboratories were used. For this alloy, the value of the constant C was 17 for the stress-rupture parameter, and 20 was used for the minimum creep rate parameter for best correlation.

Predictions of long-time rupture life from data for 10-hr. tests were made for Alclad 7075-T 6 (75 S-T 6). The agreement at 212° F. is good over the entire time-temperature range, at 300° F. the agreement is good up to intermediate times, and at 375° F. the agreement is very good for stresses up to 25,000 psi.

Reliable predictions of long-time life from short-time data are evidently possible from the use of parameters having either the theoretical or experimental basis, provided that the proper values of the constant have been determined for the material and the application.

C. O. Smith

Tests for Corrosion Resistance of Galvanized Wire*

THE MAIN sources of defects in galvanized steel wires are cracking of the protective coating on bending, and breakdown in the coating due to chemical attack. Several types of control test are commonly used to measure susceptibility to such failures.

Brittleness in the deposit is examined by means of a so-called "spiraling" test in which the wire is wound either upon its own diameter or upon an arbitrarily chosen diameter of 1.5 cm. The samples are examined for cracking with the unaided eye, and also under a low-power binocular microscope. Conclusions from this test are reasonably clear-cut and show that thin coatings are more ductile than thick ones, but that the iron content of the coating is the controlling factor. Thicker coatings are ductile, for example, if the outer layer is pure and uncontaminated with iron. There is no relationship between grain size in the wire and brittleness in the deposit.

Predicting the corrosion resistance is more difficult, and for this reason useful information or corrosion resistance can only be obtained when several different tests are employed.

Two testing procedures are used to measure, separately, the uniformity and average thickness of the coating. One of these is the Preece test for the measurement of the minimum thickness of deposit. Samples are dipped in an aqueous solution of copper sulphate under standard conditions for periods of 1 min. each. Between treatments the sample is dried, lightly cleaned, and examined. The number of immersions prior to the formation of a "shining, adherent, rose-colored film," indicating deposition of copper on bare steel, is the measure of minimum coating thickness. The other test is the measurement of average coating thickness by complete solution of zinc in dilute sulphuric acid and

(Continued on p. 174)

*Digest of "The Influence of the Quality of the Coating on the Corrosion Resistance of Galvanized Steel Wire", by Jean Herenguel, *Revue de Métallurgie*, Vol. 51, January 1954, p. 36-44.

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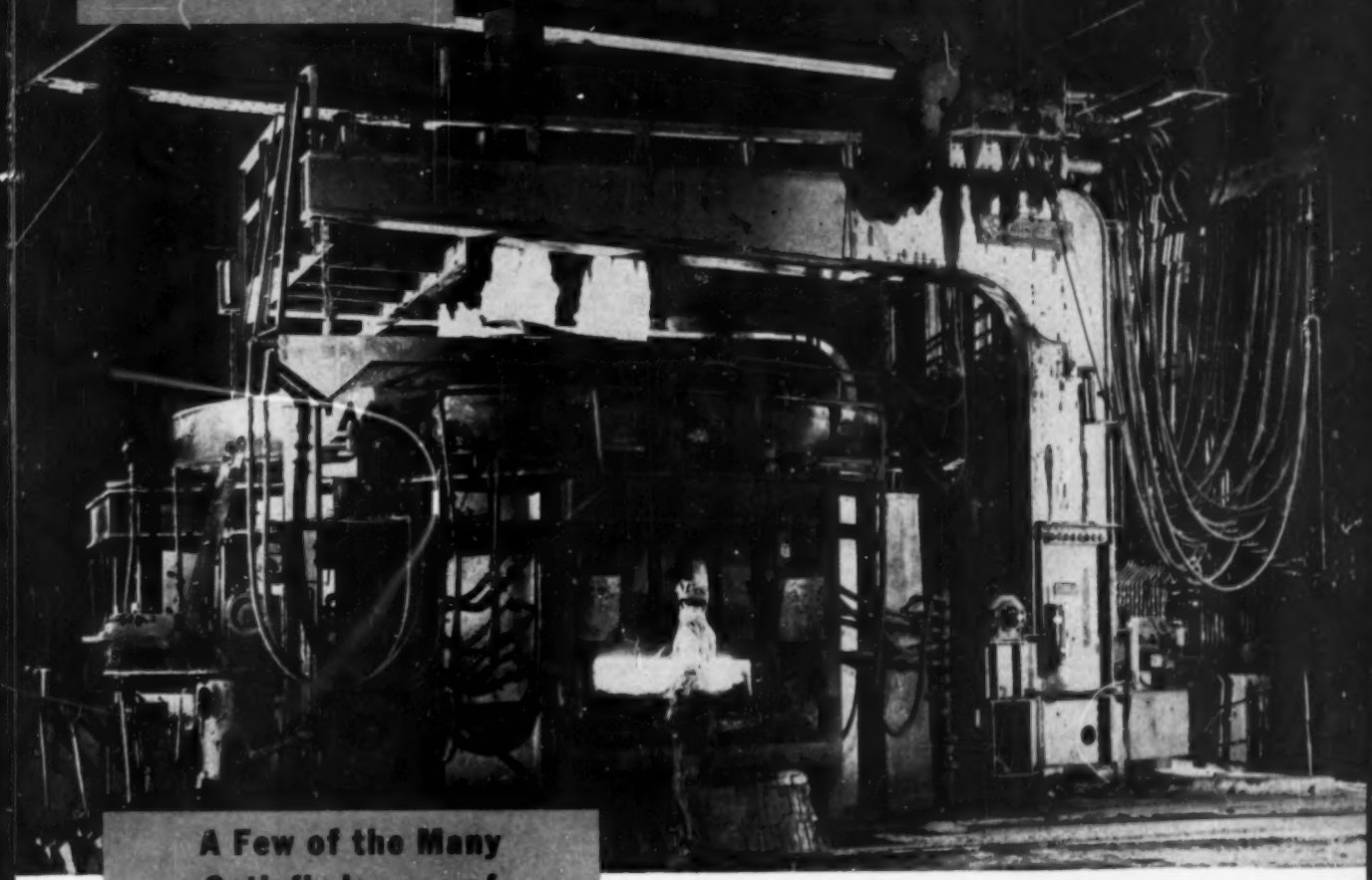

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Galvanized Wire . . .

determining the difference in the weight of the sample before and after the test as weight of dissolved zinc. It is found in practice that the two measurements are complementary and there is, furthermore, a linear relationship between W and I (W as weight of coating in g. per sq.dm. and I as number of immersions to first appearance of the underlying steel).

Additional evidence on the nature of the deposit is gained from microscopic examination, which confirms that wire in which the ratio W/I is high has a deposit of irregular thickness. An example is given in which the mean thickness was 21 microns, but the coating thickness varied between 17 and 29 microns. This high variation was associated with a high value of the ratio W/I.

Microscopically, the coating consists of two layers, an outer layer of pure zinc and an inner layer consisting of iron-zinc alloy. The relative proportions of these two layers can be confirmed chemically by treating the wires progressively for standard periods of time in a solution containing nitric and sulphuric acids. By this means it was found that a wire showing two well-defined layers contained 0.1% iron at the surface, 6% near the core, and 12% at the zone of actual contact. A coating having no pure zinc layer but consisting of iron-zinc alloy throughout had a uniform iron content of 3 to 5%.

Finally, corrosion resistance is measured in a salt spray test in which 3% sodium chloride solution is sprayed onto wire for periods of 30 min. in every hour. Samples are examined from time to time and subjected to tensile tests after exposure for periods of 10 and 15 months. Observation is made of the appearance of the first spot of rust — in thin coatings this may occur in as little as 12 days — and of the amount of rust after the full period of exposure. Wire coated with 0.5 g. per sq.dm. of zinc rusted completely after 10 months and with 0.7 g. per sq.dm. after 15 months.

It is admitted that measurement of minimum and average coating thickness made by the Preece and solution methods sometimes give anomalous impressions of corrosion

(Continued on p. 176)

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Galvanized Wire . . .

resistance, but in general these two tests when used in a complementary manner are useful for specification purposes.

Brittleness is adequately revealed by the "spiraling" tests and although some of the factors affecting it are as yet undefined, a high iron content appears to favor brittleness and bad adherence.

The salt spray test is of limited value since a few rust spots sometimes appear after a very short time, but no further deterioration sets in even after 15 months, and measurements of ultimate tensile strength are uninformative. Nonetheless, a reasonable relationship is found between average coating thickness and the development of extensive rusting in the salt spray test.

C. B. LANDER

He-N Shielding Gas Looks Promising in Metal-Arc Welding*

HELIUM-NITROGEN shielding gas for inert-gas metal-arc welding of low-carbon steel has demonstrated a number of superior properties in comparison with conventional helium-argon mixture and straight helium. Among them are a 50% reduction in welding current, lower cost of gas, improved ductility in the weld, better penetration, smaller bead and freedom from defects, such as gas pockets and heat cracks.

These are conclusions drawn from comparative tests made on samples of 0.125-in. low-carbon steel plate. Both butt and fillet welds in the form of T-joints were investigated. Specimens were in the as-sheared form, with no edge preparation.

With helium-nitrogen shielding gas, it was possible to reduce welding current by 50% from that required for helium-argon because the nitrogen present in the arc atmosphere completely dissociates at arc

(Continued on p. 178)

*Abstract of "Helium-Nitrogen Shielding Gas Improves Welding of Low-Carbon Steel", by Eugene L. Turner and Walter F. Henler, *General Motors Engineering Journal*, Vol. 1, July-August 1954, p. 9-11.

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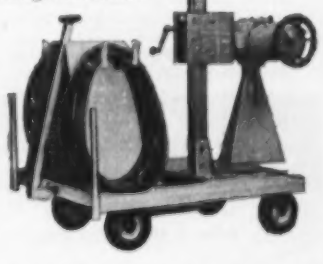

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Arc Welding . . .

temperature and its subsequent recombination of single atoms to form diatomic gas molecules liberates heat to the arc atmosphere and increases its heat-transfer ability. Thus, the arc temperature and voltage gradient are increased while current is decreased. This, in combination with the lower cost of helium-nitrogen mixture, gives an important cost advantage.

It was suspected that helium-nitrogen might cause the formation of undesirable embrittling nitrides in the weld, so an examination was made of the microstructure of cross sections from each type of weld, using either nital or picral etchants. No significant differences could be detected in the microconstituents, but it was obvious that weld penetration was somewhat higher with the helium-nitrogen shielding.

Welds with the two gases were checked for tensile strength, hardness and fatigue. Again no conclusive differences between the two could be found. However, in bend tests on samples 1 x 6 in. welded together on one side only and bent in the weld 180° over a diameter twice the thickness of the plates, or 0.250 in., fractures developed in some of the helium-argon welds but none in the helium-nitrogen samples. Test pieces were polished and positioned with the weld outside the bend.

A ⅛-in. filler wire was used with helium-nitrogen gas for single-pass fillet or butt welds. This represents a slight saving in electrode over the 5/64 or 3/32-in. wire normally employed with helium-argon gas.

Higher welding speed and a smaller, cleaner bead were other advantages obtained with helium-nitrogen. The faster, forehand technique on fillet welds permitted larger concave beads to be made. Undercutting was avoided because good wetting action of the weld metal was obtained with helium-nitrogen shielding; this resulted in a minimum restriction to the flow of weld metal up the sides of the fillet legs. A backhand technique restricts the welder's view as to direction of travel since the unwelded part of the joint is directly in front of the arc.

In a production application, the smaller bead with helium-nitrogen

(Continued on p. 180)

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Arc Welding . . .

would require less grinding of the weld before further processing. This is a significant consideration, for grinding costs frequently exceed welding costs by a substantial margin.

Advantages of shielded inert-gas metal-arc welding in terms of corrosion resistance, high welding speed, freedom from flux cleaning and reduced grinding requirements have long been recognized in the welding field. They would now appear to be enhanced by the new shielding gas.

A. H. ALLEN

Materials for 1000° C. (1832° F.)*

ONE PHASE of an attempt to hasten the slow improvement in alloys for gas turbines (good alloys are available up to 1500° F., but few are serviceable at 1650° F.) is a study at the National Physical Laboratory in Great Britain of the creep strength of the refractory metals at 1000° C. (1832° F.). Since some of them were available in pure form only in very small quantities, the samples were ¼-in. cylinders, ¼ in. long, tested in compression and in a vacuum. All samples were in the "soft" condition – that is, free from effects of cold work. Enough experiments (varying the loads) were run to estimate the stress which produced 1% strain in 24 hr., a criterion thought to represent the upper limit for commercial use.

Results are tabulated on p. 182. Since stresses in rotor blades in air engines are about 5000 psi. minimum and maybe as high as 30,000 psi., Dr. Allen concludes that very few metals in this list may be sufficiently strengthened by alloying to withstand stresses of this order at 1800° F. Iridium seems to have most of the properties required, but it is far too costly. Chromium would be very promising on a strength-to-weight basis if it were not so brittle. Molybdenum and tungsten both need to be protected from oxidation;

(Continued on p. 182)

*Digest of "Exploratory Creep Tests on Metals of High Melting Point", by N. P. Allen, *Journal*, Institute of Metals, Vol. 82, p. 525.

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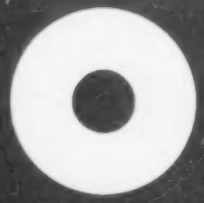

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Creep Tests . . .

of the two, molybdenum would be preferred on account of its lower density. Columbium has a good strength-to-weight ratio and is also ductile. If it can be protected from oxidation, it should be a very promising material indeed, particularly as it is capable of much hardening.

Several bonded carbides were also tested in a similar manner. The best (having creep strengths at 1830° F. about equal to molybdenum's) contained about 50% titanium carbide. The binder was 65-20-15 Ni-Cr-Co alloy. Such materials are brittle at room temperature.

The source of their creep strength is the same as that of their brittleness. Deformation takes place principally in the bonding material. This material by itself is very weak. The composite bodies deform slowly under high pressures because the hard particles cannot approach each other without squeezing the bonding material out sideways. The bonding material is restrained from making this movement by its contact with the hard particles, and a state of triaxial stress is set up which in effect raises the yield point of the binding material. There is no point in raising the shear strength of the bond to such an extent that the material becomes unusably brittle, and the only course is to maintain the shear strength of the bond in balance with the fracture stresses. Consequently, hard crystals of high cleavage strength must be chosen; they must be united firmly with the bonding materials, which must also have a high fracture stress. E.E.T.

Creep Strength of Refractory Metals at 1832° F.

Metal	Atomic Number	Creep Strength	Density Lb. per Cu. In.	Strength to Weight
First Long Period				
Titanium	22	<200 psi.	0.164	<1200
Vanadium	23	500	0.217	2300
Chromium	24	4500 to 6700	0.260	21,500
Iron	26	1000	0.284	3500
Cobalt	27	1500	0.32	4700
Nickel	28	500	0.322	1500
Second Long Period				
Zirconium	40	<200	0.23	<800
Columbium	41	6200	0.310	20,000
Molybdenum	42	6700 to 8700	0.369	21,000
Rhodium	45	6700	0.45	15,000
Palladium	46	700	0.434	1600
Third Long Period				
Tantalum	73	6700 to 9800	0.600	14,000
Tungsten	74	13,500	0.697	19,500
Iridium	77	13,500	0.813	16,500
Platinum	78	<200	0.775	<250

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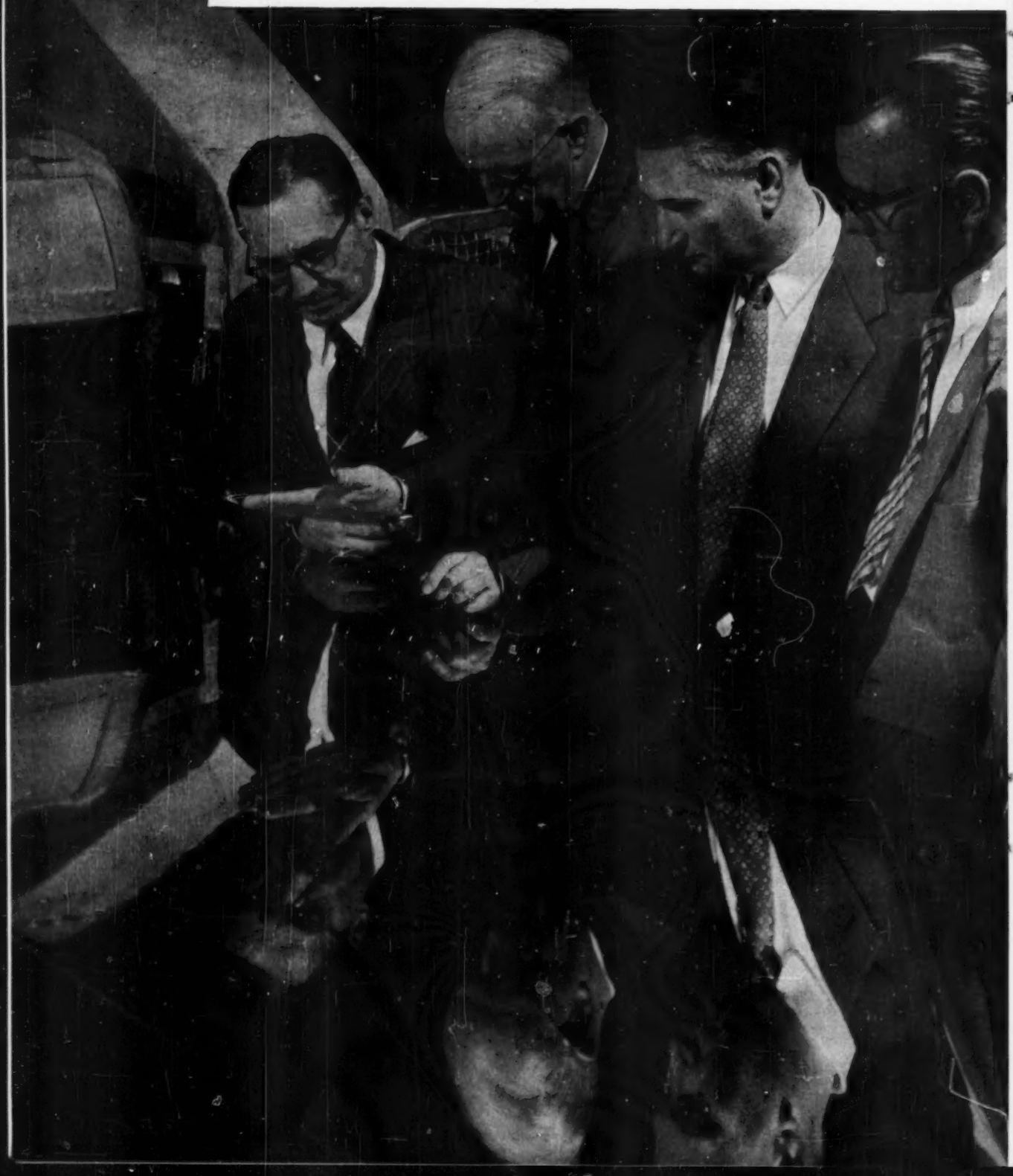
Metals Engineering



at Republic Steel

This 36 x 120-inch sheet of chrome stainless has just received its final polish at Republic before shipping for use in plastic presswork. Inspecting the high luster are: (l. to r.) Clyde E. Roberts, Sales Manager; Earle C. Smith, Chief Republic Metallurgist; V. W. Whitmer, Assistant Chief Metallurgist, Central Alloy District; J. H. Jones, Assistant District Manager, Central Alloy District; and J. H. Kennedy, Superintendent of No. 1 Electric Furnaces, Central Alloy District —all members of the American Society for Metals and readers of *Metal Progress*.

as described by

Clyde E. Roberts, *Manager of Sales*, Stainless Steel Division, Massillon, Ohio

and Earle C. Smith, *Chief Republic Metallurgist*, Cleveland, Ohio

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A publication of the American Society for Metals
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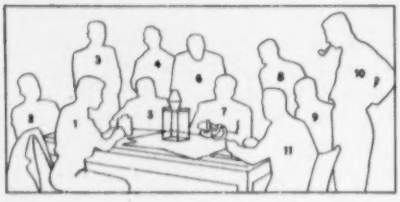

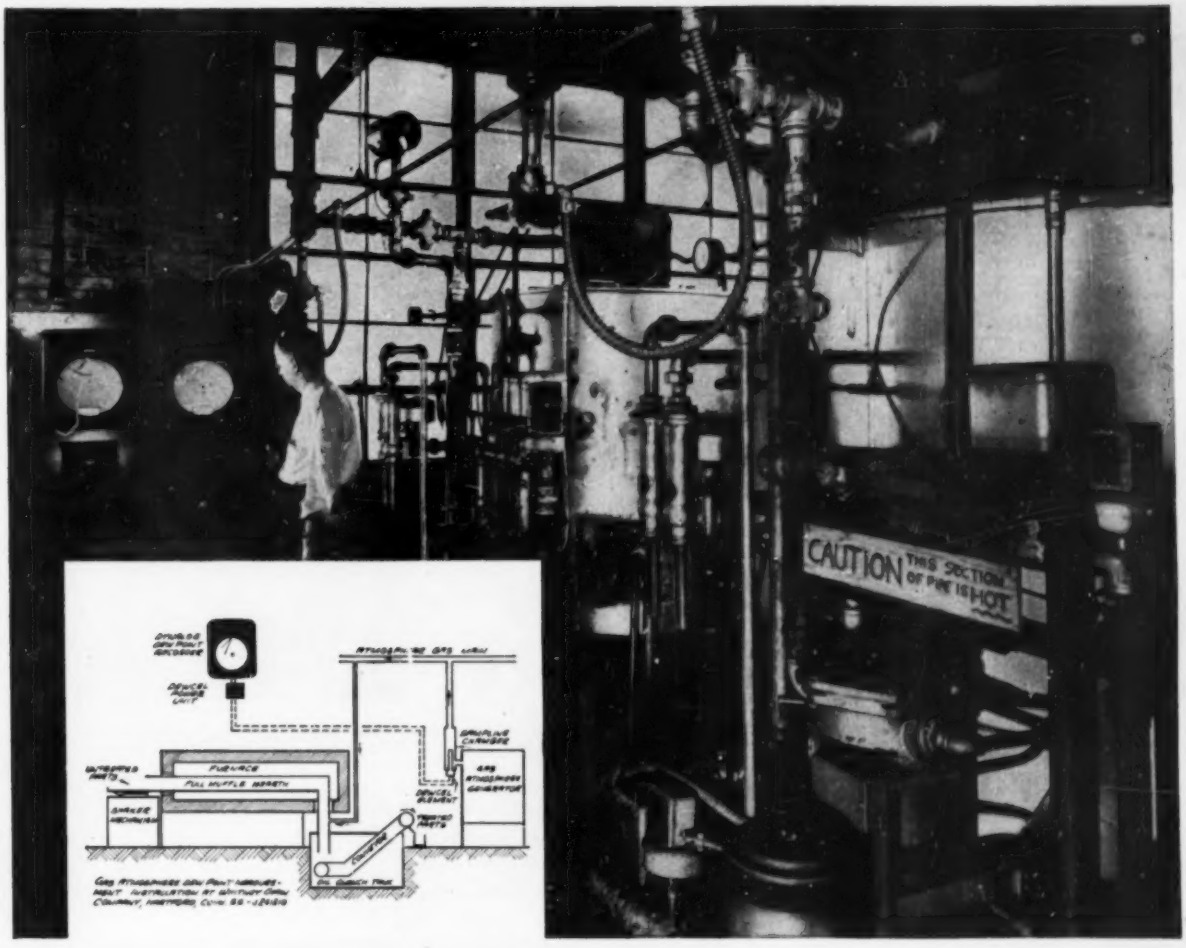

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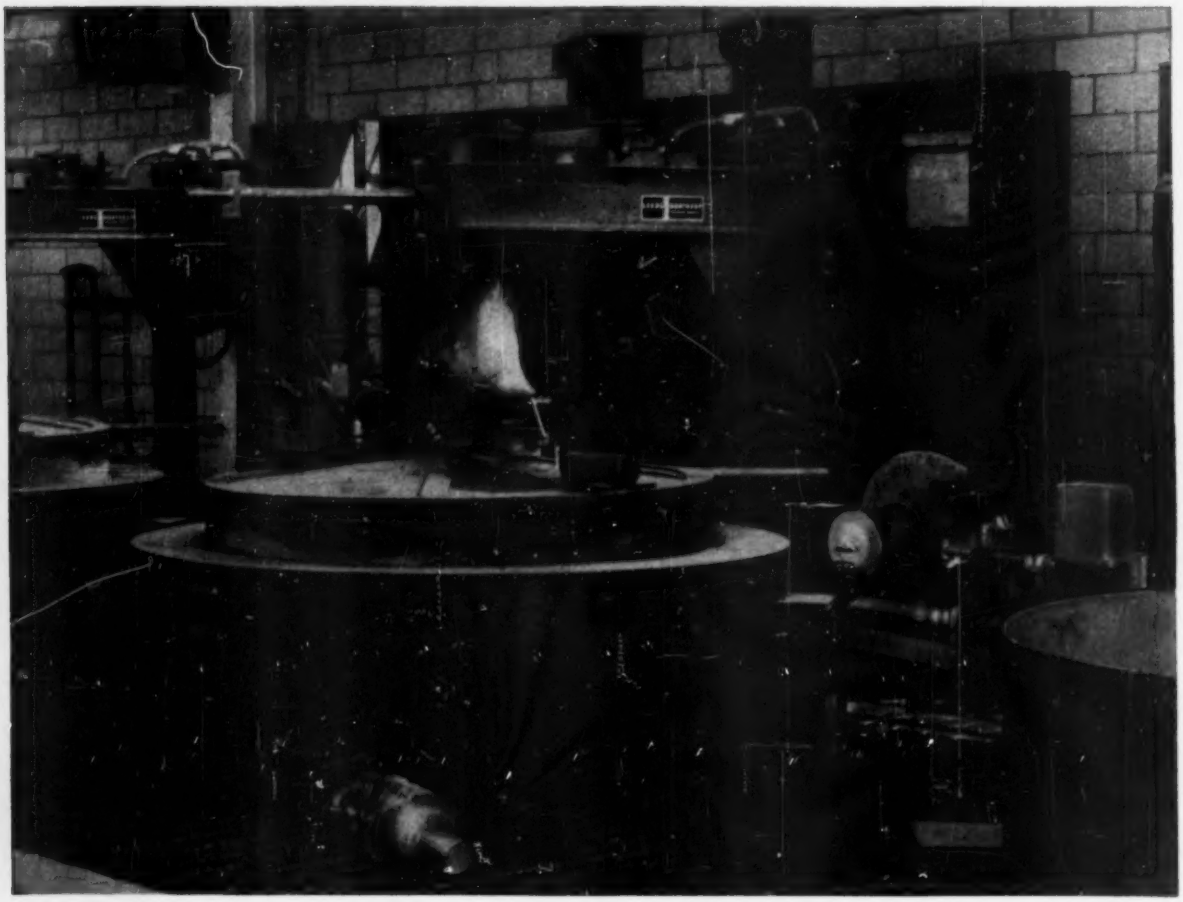

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Photo courtesy John A. Roebling's Sons Corp.

This wire is lightly scaled steel, at 400 F. It's passing through a 15-20% sulfuric-acid pickling bath at 100′ per min. Where the wires bear – along the edge of the tank, and down in the acid bath – special wear-resistant surfaces are required. You can imagine the punishment they take . . . from the semi-scaled steel; the fast moving wire; the hot acid. In fact, most materials would be sliced through in a matter of days.

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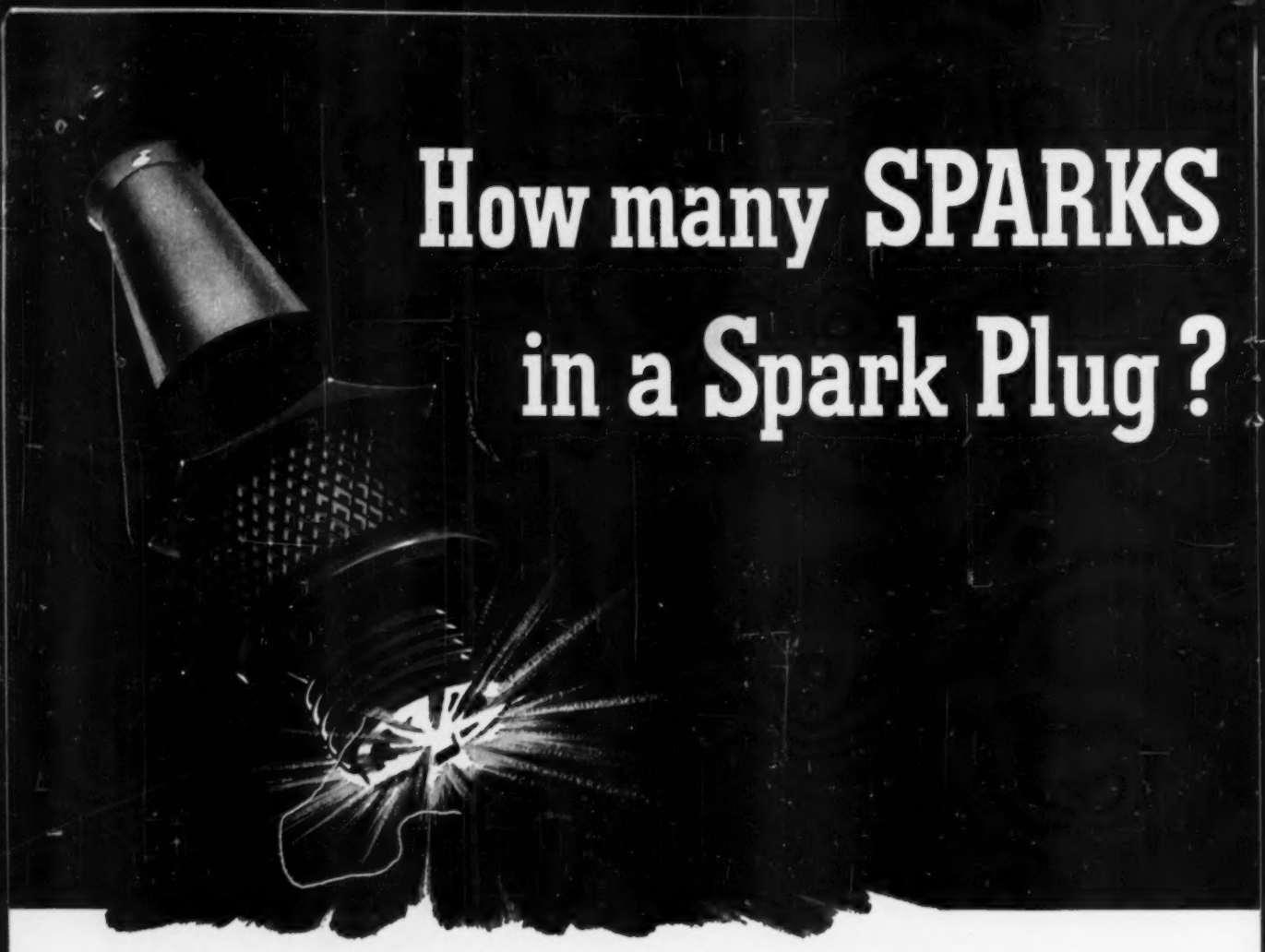

How many SPARKS in a Spark Plug?

Surprising, the confidence that people have in spark plugs. No one stops to question how many "sparks" they're good for, because long-life performance has come to be taken for granted. Yet, when you get right down to it, you'll find good reasons for this complete consumer confidence. And, from a "sparking" point of view, perhaps the most important is the almost universal use of special Hoskins alloys for the vital electrode wires.

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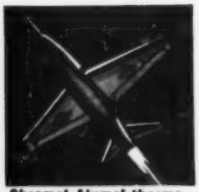
Yet that's exactly the kind of alloy that Hoskins is qualified to produce best. For, among the other quality-controlled alloys developed and manufactured by Hoskins are: Alloy 717—for facing engine valves; Alloy 785—for brazing belts; Alloy 502—for countless heat resistant mechanical applications. Then, too, there are the Chromel-Alumel thermocouple alloys . . . guaranteed to register true temperature-EMF values within specified close limits. And, of course, Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.

Hot stuff for hot jobs! Hoskins Alloy 502 is ideally suited to many mechanical-structural applications.

Heating elements made of Hoskins Chromel deliver full-rated power throughout their long and useful life.



Chromel-Alumel thermocouple alloys accurately measure exhaust temperatures of jet aircraft engines.

Chromel NICKEL CHROMIUM WIRE

HOSKINS

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For complete details of contents, see your July 15, 1954, issue of Metal Progress . . . which contains all the articles now being offered in this cloth-bound edition. Price is $4.00 to ASM members, $5.00 to nonmembers.

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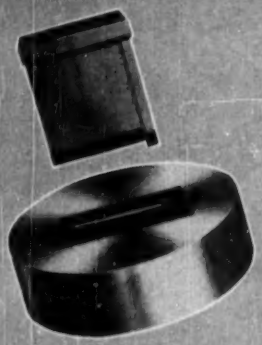
Production Records Prove *Talide Dies* Save You Money

● 137,000 hi-alloy steel Pressure Vessels deep drawn through a TALIDE Sheet Metal Die—with buffing and polishing costs cut 80%—down-time 98%—and scrap 100%. Best production from steel die used previously was 7,900 cylinders before wearing oversize.



BLANKING AND FORMING DIES

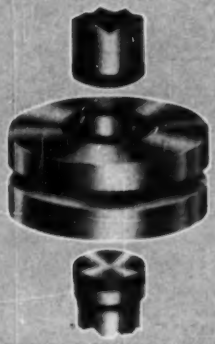
Over 5,000,000 abrasive paper discs blanked out with a TALIDE Blanking Die—70 times more than produced with hard alloy dies used previously.

HEADING AND EXTRUSION DIES

Costly cold-heading job on 3/4" carriage bolts producing only 50,000 pcs. per steel die made profitable with average 1,500,000 piece production runs with TALIDE Cold-Heading Dies.

CURLING ROLLERS

Large Can Company reports TALIDE Curling Rolls last 65 times longer than steel rolls on beverage can forming operation—with edges free from burrs and cracks.

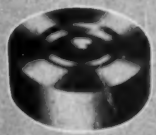


POWDER METALLURGY DIES

Large Pharmaceutical Company reports TALIDE Pill Dies not only produce tablets having a superior surface glaze which reduces rejects 82%—but also outlasts steel dies 100 to 1.

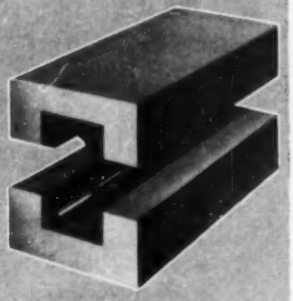
TUBE MANDRELS

12 days (36 shifts) of continuous trouble-free production obtained by eastern Brass Mill with TALIDE Tube Drawing Mandrels—compared to average 8-hr. runs obtained with steel mandrels.



DRAWING DIES

50 miles of tough 5" alloy steel tubing (actually 252,000 ft.) drawn by large mid-western Steel Mill through TALIDE Tube Die compared with a normal run of 10,000 ft. with a steel die.



SWAGING DIES

Leading Fountain Pen Manufacturer cold swages an average of 750,000 stainless steel sleeves with TALIDE Swaging Dies — 33 times more than with chrome-plated dies.

● Available in size range from .010 to 24" I.D. and in any shape, Talide Dies meet every requirement. Uniform quality and consistent performance are assured by 21 grueling tests including physical, chemical and metallographic. Send us prints or parts of your particular die application for estimate and recommendations. **Metal Carbides Corp., Youngstown 7, Ohio.**

Send for new 84-page Catalog 54-G or ask for sales engineer to call.

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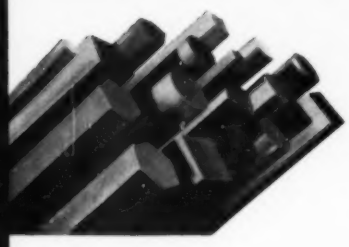
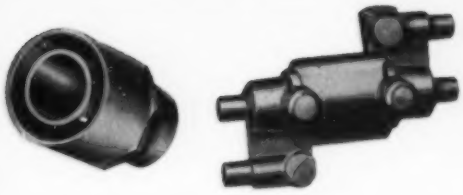
HEAVY METAL · CERMETS · HIGH TEMPERATURE ALLOYS
OVER 25 YEARS' EXPERIENCE IN TUNGSTEN CARBIDE METALLURGY

Brass and Bronze Free-Cutting Rods



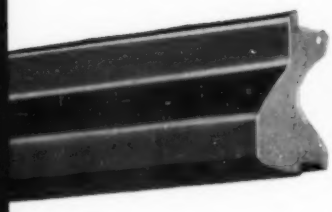
Furnished in all sizes from 1/8" for small-diameter rods up to 10" for cast and turned rounds. The most easily-machined of all metal alloys.

Brass and Bronze Forgings



From 1/4 oz. to 100 lbs. in weight. Produced to meet requirements of uniform dimensions, finish and physical properties.

Extruded Brass Shapes



Squares, hexagons, half rounds, half ovals, and special shapes. Extruded-only rectangles furnished up to 3½" maximum diagonal. Extruded, drawn, machine-straightened hexagons up to 4", rectangles up to 3½" maximum diagonal.

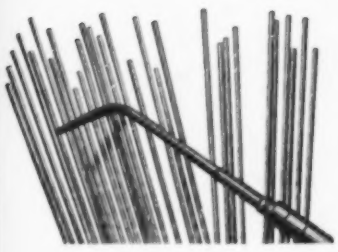
Brass Pressure Die Castings

Parts having thin sections and intricate cored parts readily produced. Titan die castings have better finish, stronger structure and greater accuracy than sand castings.

Titan Brass and Bronze Products

Titan brass and bronze products are supplied in analyses to meet every requirement. Write for descriptive catalogs.

Bronze Welding Rods



Eight different types meet all requirements. Titan's exclusive Double Deoxidation process assures ductile, high-strength, non-porous welds with the oxyacetylene torch.

Brass Cold Heading Wire

Brass wire for manufacture of rivets, bolts, screws, fasteners, etc.

Titan

METAL MANUFACTURING COMPANY

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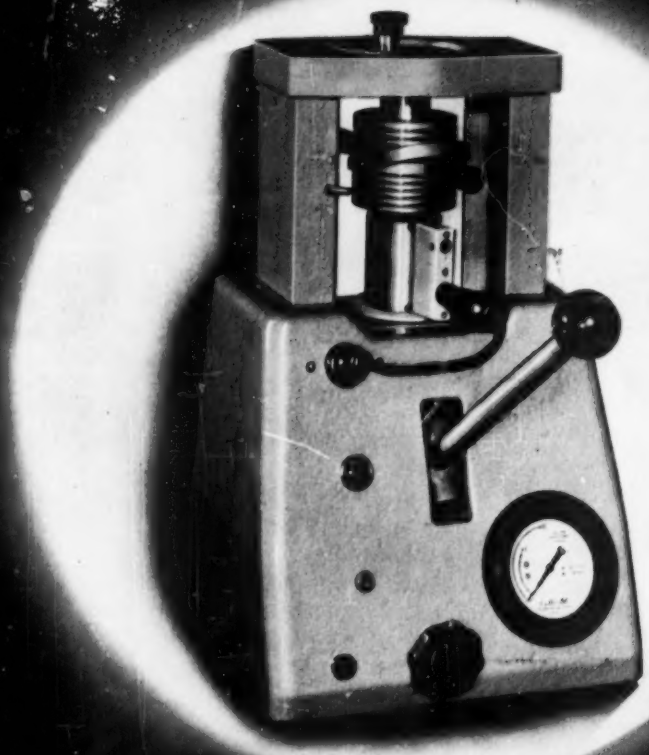


CENTERMET PRESS

Latest design in Press equipment for processing Bakelite and Transoptic mounted micro samples is now offered to the Metallographic Laboratory.

This new Press provides practical center ejection of 1" or 1¼" mounted specimens. The heating unit is controlled by thermostat and need not be removed from the press structure. The cooling block rigidly encloses and holds the mold assembly.

Minimum amount of handling molding accessories, speed and ease of sample ejection, practical and economical operation of molding tools were paramount in the development of this new AB Centermet Press.

Buehler Ltd.

METALLURGICAL APPARATUS

2120 GREENWOOD at Hartrey Ave., EVANSTON, ILL., U. S. A.

Titanium Silver Brazed Under Inert Gas*

How to seal hermetically the joints in a titanium sphere assembly (guided missile component) against a helium leak rate equal to or less than 2.5×10^{-8} cc. per sec. and still allow dissassembly and reassembly without injury to the contents was a problem presented to North American Aviation Inc., Downey, Calif.

The sphere comprises five parts – two end caps, two semispheres and one center ring – making four joints to be sealed. Three procedures were developed to produce a hermetic seal by soldering: *(a)* Braze a solderable material within the sealing area; *(b)* provide a silver overlay within the sealing area; or *(c)* solder directly by the Heliarc process. The first two permit soft soldering by conventional techniques. In applying a silver overlay, the metal is deposited with a Heliarc torch that is powered by a high-frequency alternating current.

The low thermal conductivity of titanium and its proclivity to absorb oxygen, nitrogen and hydrogen at brazing temperatures require a process that will produce quick, local and uniform heating, shielding against atmospheric contamination and moderate cooling. To accomplish this an inert-gas induction brazing "platform" was devised for doing the job without the need for flux. The platform carries a focus inductor work coil, powered by a 20-kw. induction spark-gap convertor to give the required heating, and a bell jar assembly which forms the chamber for the inert gas protection.

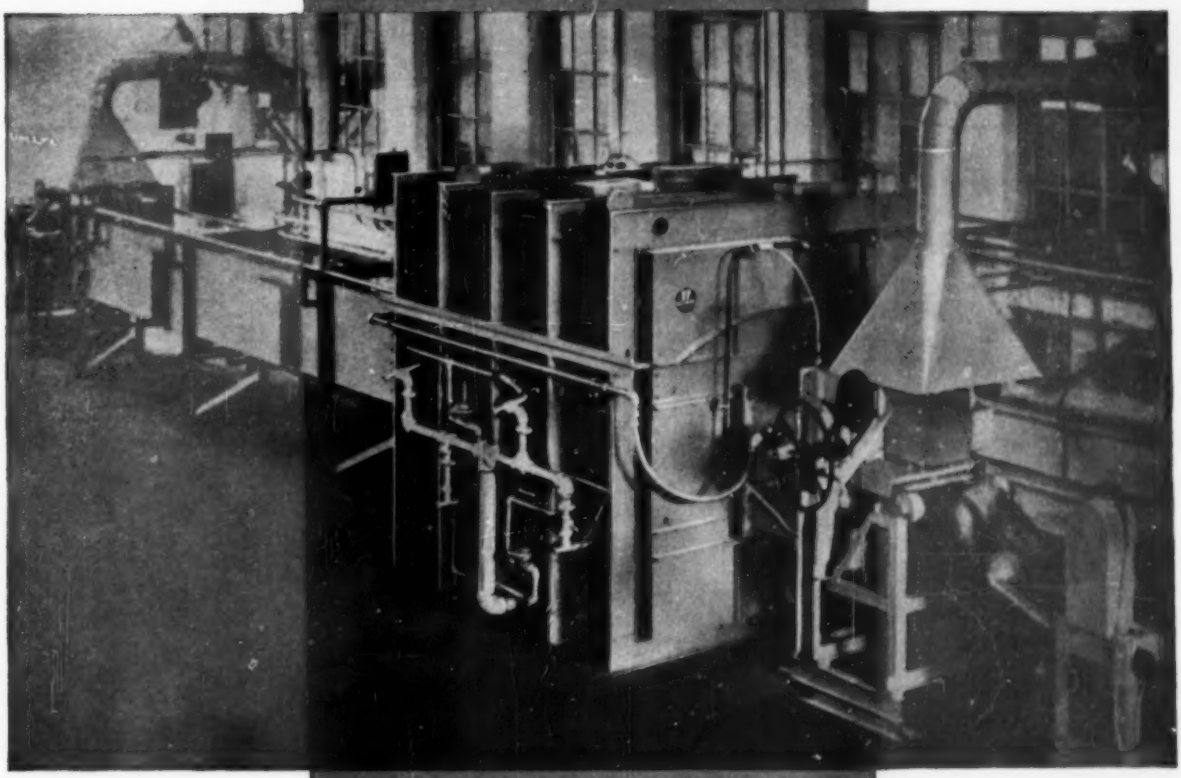
General brazing procedure adopted in a program involving the brazing of various types of tension-shear test specimens was to clean the joint area by vapor blasting or pickling in 50% orthophosphoric acid solution at 150° F., then rinsing and drying in compressed air. Immediately thereafter, filler metal was introduced into the joint interstices by laying 0.002 to 0.005-in. thick ribbon stock on top of the grooved half of the specimen and then forcing it into place by the tongued end of the other half. Then the specimen was mounted rigidly in an insulated jig, the bell jar was lowered and the chamber was purged with a flow of inert gas. Induction heat was applied until the filler metal melted and flowed through the joint, the flow of protective gas being maintained until the temperature dropped below 900° F.

Three types of filler metal employed in brazing the tension-shear test specimens were a pure silver, a eutectic silver-copper binary alloy, and a silver-copper-cadmium-zinc quarternary alloy. The tensile strength of the specimens was obtained in a testing machine that was set to register in the 0 to 20,000-lb. range; elongation (as inches per inch) was obtained with destructive testing of a 2-in. gage length, and the ultimate shear allowable for the joint was computed by assuming a uniform brazed area of 0.375 sq.in.

(Continued on p. 198)

*Digest of "Inert-Gas-Shielded Titanium Brazing", by Harlan L. Meredith, *Welding Journal*, Vol. 33, June 1954, p. 537-542.

Gas-fired furnace used for continuous bright annealing on the 25" high-speed stainless steel strip line at Rodney Metals, Inc., New Bedford, Mass.



Rodney Metals finds GAS best for annealing, brightening, paint baking

At Rodney Metals, Gas does three separate jobs. First, a Gas-fired furnace bright anneals stainless steel strips in widths up to 25" and thicknesses down to 0.002". Also, in a bell-type furnace used to box anneal carbon strip to a bright finish, Gas as a protective atmosphere reduces oxidation to a minimum. And third, a Gas-fired oven bakes vinyl and enamel finishes to steel and aluminum strip—so well that they won't crack or peel, even when the metal is drawn to its limit.

Is there a problem spot in your production line? Could clean, even-heat Gas help? Modern Industrial Gas Equipment is designed to improve and blend in with production-line techniques wherever heat is required in processing operations. When you have a problem in your production line involving heat processing, call your Gas Company representative. He'll be glad to discuss the economies and results you can expect from using Gas and Gas-fired equipment.

American Gas Association

MORE AND MORE THE TREND IS TO GAS

420 LEXINGTON AVENUE, NEW YORK 17, N.Y.

Brazing Titanium . . .

The joint area was determined in advance so that all fractures would occur along the jointing interface. When fracture was indicated by the testing machine, the load was released to avoid pulling the specimen apart. In this way the elongation could be measured as accurately as possible without postfitting. The double-lap tension-shear specimens used in the study were made of MST Grade IV hot forged bar stock of commercial purity.

One difficulty with this type of rectangular-shaped joint is that the joint interstice widens appreciably and the resulting interface alloying is concentrated at the corners. Nonuniform interface alloying is due to the type of magnetic field developed by a rectangular two-turn helical induction coil, coupled with the relative mass of the corner with respect to the sides of the specimen. To correct this condition, a shaft-insert specimen with lap joint was devised and tested. This joint is symmetrical and a minimum of coupling action is encountered during loading in tension.

Shear strengths equivalent to the tensile strength of annealed commercially pure titanium (32,000 to 36,000 psi. shear ultimate) are obtained by using joint interstices of 0.002 to 0.003 in. of pure silver filler metal. The brazing was done at 2100 to 2500° F. for 15 to 10 min., respectively, after complete flow of filler metal is observed.

Shear strengths in the range of 24,000 to 27,000 psi. are realized with interstices of 0.002 to 0.005-in. pure silver filler metal and brazing temperatures of 1900 to 2100° F. held for 15 to 25 min., respectively. Brazing temperatures of 1800 to 1900° F. held long enough for the filler metal to flow completely give shear strengths in the range of 20,000 to 22,000 psi.

Pure silver proved to be one of the better filler metals; silver-manganese showed good promise, although relatively more expensive. Copper-bearing alloys should be avoided for joining titanium to itself until consistent strength levels can be produced.

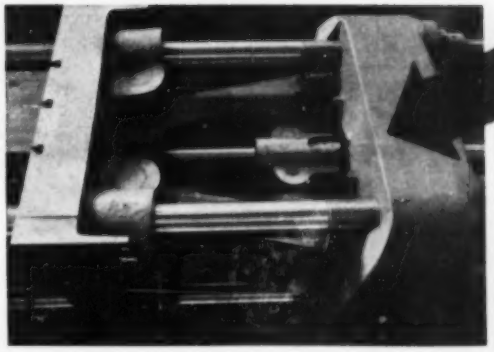
Photomicrographs of joints brazed with silver show a diffusion layer of an intermetallic compound of titanium-silver, formed apparently by a binary reaction in which the solid phase (titanium) and the liquid phase (silver) combine during cooling to form a second solid phase. The layer of silver filler metal contains titanium carbides. The titanium-silver phase, however, is usually discontinuous across the joint, its extent and depth depending upon time and temperature of brazing. Thus, high brazing temperatures (2200 to 2300° F.) held for 15 min. produced joints that withstood failure, the failure occurring in the parent metal (32,000 to 36,000 psi. ultimate shear), but excessive grain growth and a decrease in ductility occurred in the heat-affected area.

The data on the shear strength show that no gain in strength is derived from narrow interstices. The same strength may be obtained with a 0.001 or 0.010-in. wide interstice. The difference is that the narrower one requires relatively shorter brazing time and less filler metal for equivalent strength.

ARTHUR H. ALLEN

REPETITIVE PURCHASES PROVE SUPERIORITY

of Lake Erie Die Casting Machines

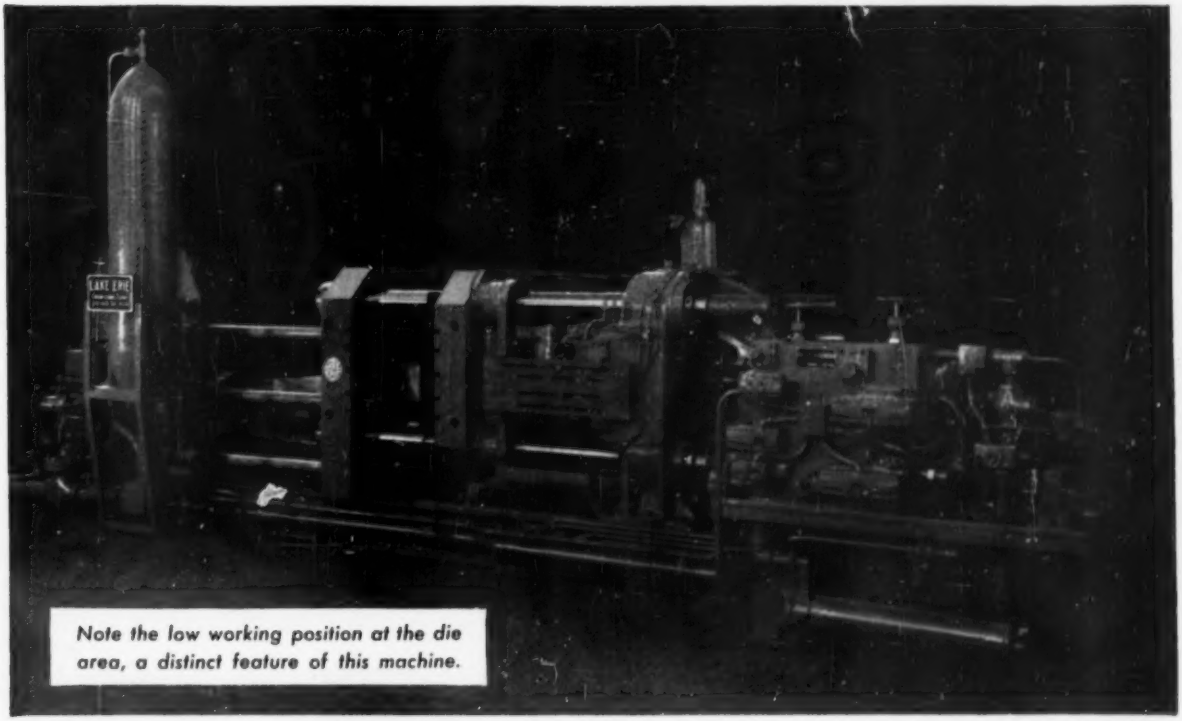


The Wedge Cam Toggle is ...elf-compensating clamp ...*automatically* takes up ...nces in the dies due ...ontraction and expansion of the molds during production or shut-down periods.

●

Pressure-Pac is a patented automatic pressure booster that produces sounder castings by feeding the shrink or compressing the porosity at the time of solidification of the metal.

● *Over 40 Lake Erie Die Casting Machines are now in service at The Electric Auto-Lite Company's plants.*



Note the low working position at the die area, a distinct feature of this machine.

Lake Erie die casting machines bring you features long desired but never before available in die casting equipment. The patented "Wedge Cam Toggle" and "Pressure-Pac" injection unit are the first major improvements in die casting equipment in many years. Repetitive purchases of these machines by companies like The Electric Auto-Lite Company, Ternstedt Division of General Motors and others assure you that Lake Erie equipment has no equal for quantity or quality of die castings. (Ask us about the new 16mm film describing Lake Erie machines.)

TYPICAL USERS of Lake Erie Die Casting Machines

Allis-Chalmers Mfg. Co.
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General Controls
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Westinghouse Electric Corp.

***WRITE** for Bulletin 23.2 — Contains Machine Specifications, Pressures, Capacities, Speeds, etc.*

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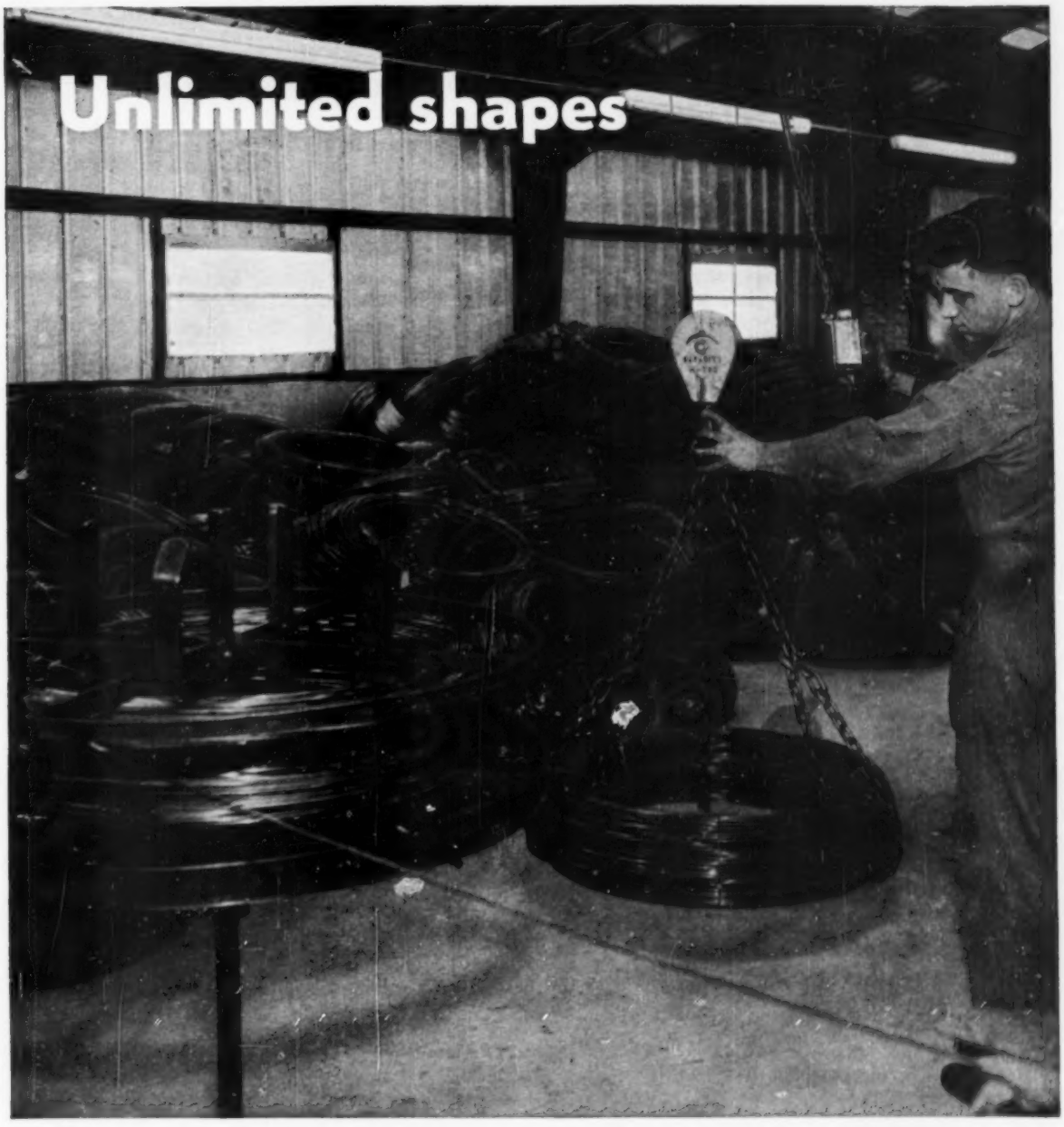

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Burning Issues

Eclipse

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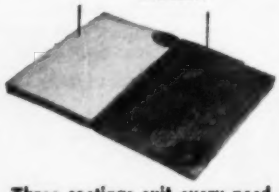
At less cost, with less fuel for heating, you can *double, even triple* average service life of pots. Eclipse metalized pots provide all the advantages of a seamless steel container *plus* a heat resistant outer surface for a maximum protection from corrosive action of hot gases common to high temperature heat treating.

at 1780° metalizing protects!

at 1780° untreated pot shows oxidation, scaling and metal breakdown.



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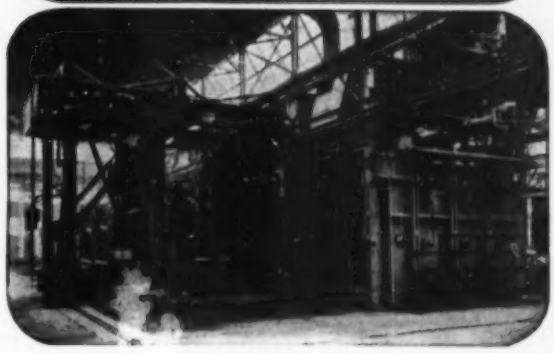

Heavy castings, plate, weldments and other products are heat treated in these EF furnaces. Gantry cranes simplify loading, unloading and quenching.

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